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VOLUME 87 DECEMBER, 1948 NUMBER 6

THE PATTERN OF VASOSPASM FOLLOWING ACUTE ARTERIAL AND VENOUS OCCLUSIONS

A Micrometric Study

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THE present study is concerned with the micrometric measurement of changes in caliber of the smaller radicals of the mesenteric vascular tree following occlusion of the superior mesenteric vessels. Our interest in the problem of vasospasm following vascular occlusions arose while studying the response of mesenteric vessels to intestinal strangulations (23). We were impressed by the importance of residual vasospasm in the involved vasculature following release of the strangulations at operation. Such vasospasm apparently had a marked influence on the recoverability of strangulated bowel. The study also showed that regardless of whether the strangulations were primarily venous or arterial, vasodilating measures were of great value in resuscitation. From a review of the literature on the pathological physiology of peripheral vascular occlusion, it appears that the mesenteric vessels behave no differently than the branches of mainstem vessels in other parts of the body following occlusions (2). Therefore, our studies, which were undertaken primarily to investigate the importance of vasospasm in intestinal strangulations, have led us into much broader fields. The implications of our findings might find application in the nature of most other vascular occlusions.

From the Department of Surgery, Northwestern University Medical School, Chicago.

TECHNIQUE

Through the generosity and co-operation of Dr. M. H. Kniseley and his associates of the Department of Anatomy of the University of Chicago, we were able to utilize a modification of the Kniseley fused quartz rod transillumination apparatus (18, 19). The main features of this apparatus are the employment of a cold light source and a constant temperature bath with variable volume flow. The apparatus was constructed essentially as shown in Figures 1, 2, and 3. A Leitz micrometer lens was installed in the microscope lens system. Young, small dogs were used in all experiments, and intravenous nembutal anesthesia.

A special lucite tray was constructed to hold the dog's mesentery in a nonstretched position submersed in constantly circulating mammalian Ringer's solution at body temperature. The tray, as shown in Figure 4, was built with a lower compartment through which water circulated. This lower layer served to disperse the quartz light after it emerged from the end of the quartz rod in order to do away with the theoretical consideration that even cold light will produce warmth at the point of contact with the tissue.

The microscope was fixed on small vessels. In the mesentery a small vein and artery run side by side as a rule. Such a field gave us a very satisfactory view of both the arterial and venous responses. Precapillary vessels, the artery measuring from .054 to .144 millimeter, the vein from .090 to .288 millimeter, were chosen rather than the more minute vessels or capillaries, since more accurate changes in caliber could be measured at 48 diameters. The capillary bed varies from one field to another to such an extent that the information derived from viewing capillary vessels alone is not always pertinent. Furthermore, the reaction of the capillaries does not always parallel that of the slightly larger vessels.

Six control animals, allowed to remain in the apparatus for from 4 to 8 hours, showed no appreciable changes in caliber in the observed vessels. Thus, any marked changes which occurred in subsequent experimental animals were considered dependable as a response to the lesion produced.

VENOUS OCCLUSIONS

In 40 animals the superior mesenteric vein was clamped with a rubber-tipped artery forceps for periods ranging from 20 minutes to 2 hours 29 minutes. In order to obviate the possibility that the superior mesenteric artery might be stimulated into spasm by operative trauma, the procedure was carried out in the following manner. The vein was carefully isolated and a loop of stout string placed loosely about it. The intestines were then returned to the abdomen and the abdominal wall closed temporarily by clamps. The animal was allowed to remain in this condition for periods up to an hour. The mesentery was then gently placed on the lucite tray and submersed in Ringer's solution. A control series of readings was taken to make sure that no undue changes in caliber resulted from the operative manipulation. The loop placed about the superior mesenteric vein was then drawn up and a rubber-tipped artery forceps placed on the vessel. It was allowed to remain in place for varying periods of time, while measurements were made on the vessels in the microscopic field. The clamp could be removed without reopening the abdomen.

The pattern of response in the observed vessels was remarkably uniform. In each of the few instances of failure to observe the usual responses, the failure was due either to an overzealous dissection of the vessel from its fatty bed[1] or to the presence of one or more accessory vessels which carried enough blood to make the occlusion incomplete. Upon ligation of these vessels, the occlusion of the main stem produced the same responses in the smaller vessels as were seen in all other animals.

Following venous occlusion there was invariably a marked spasm (decrease in caliber) of the small artery and a gradual dilatation of the concomitant vein. In some instances of venous occlusion, the artery diminished to 1/8 its original caliber. In 7 dogs the clamp was allowed to remain in place until death of the animal. Most of these animals died in shock within 3 hours. Plasma and blood loss from the mesenteric and intestinal vessels is responsible for this shock. In 33 dogs the clamp was released after a period of occlusion, and measurements were made up to 2 hours following release.

In the animals with venous occlusion persisting until death, the artery, after a period of marked spasm, sometimes relaxed slightly just before death; other times a state of spasm persisted. The latter usually occurred when a thrombus formed in the artery. However, only rarely did this terminal loss of tone result in a diameter as large as the control. In other words, the arteries were still slightly narrower than the preocclusion caliber during shock and at the time of death despite slight secondary relaxation. The concomitant vein, after a period of dilatation, usually became slightly narrower just before death. Occasionally it became even narrower than the preocclusion caliber.

Usually within 30 minutes of a venous occlusion the flow of blood in the vein slowed down until the stream was barely moving. At this stage there was still a rather rapid flow in the spastic artery. Groups of cells within the

[1]It is known that the sympathetic nerves of the mesentery follow the course of the main blood vessels. Therefore, stripping the main stem mesenteric vessels of nerves eradicates sympathetic responses in the mesenteric vascular tree. In the extremities, however, the sympathetic nerves reach the vessel in a segmental manner, making perivascular sympathectomy an incomplete procedure.

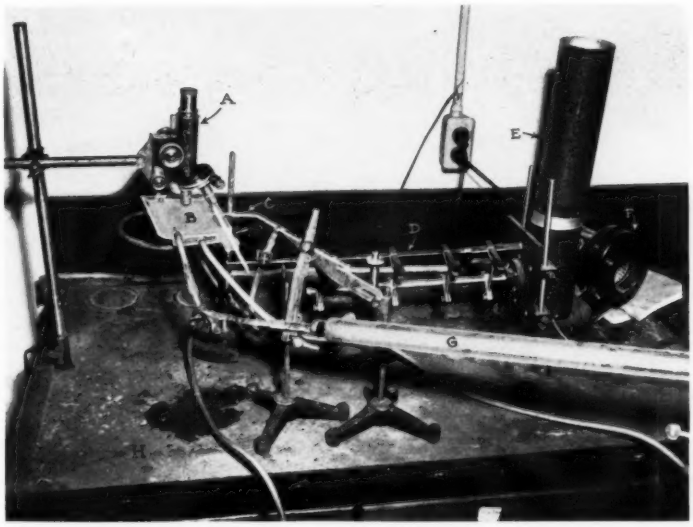

Fig. 1. Detail of fused quartz rod transillumination apparatus. Microscope (*A*). Double layer lucite tray (*B*). Spray for Ringer's solution (*C*). Kniseley quartz rod apparatus (*D*). Metal shield (*E*) containing 200 watt projector type bulb. Air blower (*F*) mounted on sponge rubber. Condenser (*G*) has inner jacket containing Ringer's solution feeding into upper chamber of lucite tray, and outer jacket containing water leading into lower chamber of tray. Steel tray (*H*) mounted on sponge rubber with drain hole in left lower corner.

artery were seen to agglutinate and travel in clumps. In a few instances the artery narrowed down to allow only a single file of cells through it. In such cases the clumps usually traveled in spurts, being caught momentarily here and there on the wall of the artery. We were impressed with the possibility that such clumps can conceivably be the source of local propagating thrombi or distant emboli. The early stage of such clumping has been termed "sludge" by Kniseley (20). Kniseley and coworkers found that sludge forms in many diseases as well as in traumatic shock. Because the venous stream is so slow at this stage, the clumping within the vein cannot be recognized as readily, but just before the venous flow ceases, it becomes quite apparent from the irregular outline of the slowly moving stream that agglutination has occurred. At first this is only a microscopic agglutination, since cutting such a vein at this time will result in the free flow of blood from the lumen.

The behavior of the capillaries during venous occlusion does not necessarily follow that of the vessels described above. Almost immediately after the vein is occluded, the capillaries become greatly dilated. Within 5 to 10 minutes of a venous occlusion of the mesentery, small ecchymotic hemorrhages occur due to overstretching and rupture of the capillary walls. This reaction of the capillaries to venous occlusion is by no means uniform. Some fields of the same mesentery exhibit such marked constriction that the capillaries are almost indiscernible. Sludge forms in the capillaries within a few minutes after venous occlusion. The difference in reaction between the precapillary vessels and the capillaries agrees with the observations of several other investigators made during experiments with widely divergent purposes (21).

After the clamp is removed from the main vein, the small arteries remain in a spastic condition for varying periods of time. This residual spasm following the release of a venous occlusion apparently plays an important role in the question of viability in strangulated intestine (23). The duration of the

Fig. 2. Detail of water bath. Pump (*A*) for pumping water heated to 41 degrees C. into outer jacket of condenser (*B*). Bimetallic thermoregulator (*D*) with relay (*C*). Wash tub (*F*) serves as water bath. Lead coils (*G*) carry Ringer's solution supplied through tubing (*J*) for warming in bath and leading into inner jacket of condenser (*B*). Motor (*E*) for spinning mixing rod to stir the water in bath. Two heating electrodes in wooden holder (*H*). Thermometer (*K*) dips into water bath.

arterial vasospasm following venous occlusion varies considerably from one animal to another, but apparently has some relation to the duration of the original occlusion. For example, in one animal (Dog No. 9) with a venous occlusion of 20 minutes, the artery regained its original caliber 15 minutes after the clamp was released. In another animal (Dog No. 14) with a venous occlusion lasting 27 minutes, the residual spasm persisted for 25 minutes. In another instance (Dog No. 11), the ligation lasted for 1 hour, and residual spasm in the small arteries was present until the death of the animal almost 2 hours after release of the clamp. Although in an occasional animal the residual arteriospasm was very short-lived and bore little relation to the duration of the occlusion, there was some residual vasospasm in every instance of complete occlusion.

The pattern of behavior of the smaller radicals following venous main-stem occlusion can be summarized as a moderate dilatation of the veins and marked spasm of the arteries. Following release of the occlusion, the vein soon returns to its normal caliber, while the artery persists in a state of residual vasospasm for varying periods of time. The capillary vessels do not follow the pattern of the precapillary artery or the postcapillary vein. Capillary behavior, in general, following venous occlusion is one of marked dilatation, but certain areas of the capillary bed are in marked spasm at the same time.

ARTERIAL OCCLUSIONS

The same technique was used for occlusion of the superior mesenteric artery in 21 dogs as was used in the case of the vein. The clamp was allowed to remain on the artery for periods ranging from 5 minutes to 2 hours.

The pattern of response of the observed vessels was again rather constant. The difference between animals was only one of degree. In each instance the small arteries responded by a marked spasm. In most animals the concomitant vein also went into a moderate degree of spasm following arterial occlusion. The gut became very white, contracted, and exhibited the typical "rippled" appearance of superior mesenteric artery occlusion.

Upon release of the clamp from the artery, the bowel flushed with reactive hyperemia. The interesting feature of this period of reactive hyperemia is that the small artery under observation maintained a definite degree of residual spasm, while the capillaries became markedly dilated. This was a disturbing observation, since all previous studies (12, 30) on reactive hyperemia employing such indirect measurements as blood flow, temperature, etc., indicate that the flow during reactive hyperemia is increased. Since most studies on reactive hyperemia (12) were carried out with short term (5 and 10 minute) occlusions, we ran a series of 7 short term occlusions. Our findings were no different than in the longer periods of ischemia. The small arteries maintained a definite state of spasm in the face of gross flushing of the tissues upon

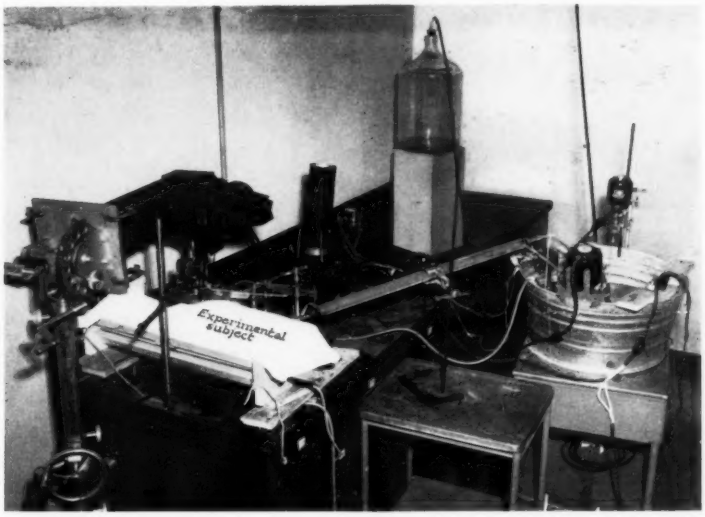

Fig. 3. View of complete setup with camera in place for taking photomicrographs or motion pictures.

release of the occlusion in all but 1 instance. In this 1 case the caliber of the artery reached the preocclusion caliber, but did not exceed this diameter at any time during reactive hyperemia.

Following arterial occlusion the blood in the artery slows markedly and stops within about 10 minutes. The blood in the vein runs a rather parallel course. Clumping of cells within the vessels occurs as the stream slows down in both the narrowed artery and the narrowed vein. Thus, we observed the mechanism of segmental venous thrombosis in arterial occlusions.

Upon release of the clamp, the artery does not usually regain its original caliber for a considerable period of time. For example, when the superior mesenteric artery was clamped for 1 hour (Dog No. 22), the residual arterial spasm following the release of the clamp lasted until the death of the animal 1 hour and 30 minutes later. However, the same relationship between the duration of occlusion and residual vasospasm does not seem to hold as it does in most cases of venous occlusion. Thus, in another case of arterial occlusion (Dog No. 23), the artery was clamped for 1 hour and 10 minutes, but it regained its original caliber within 15 minutes after release of the clamp. An interesting observation was the fact that in some instances of long term arterial occlusion the dogs died in a state of shock within 3 hours *after* the release of the arterial occlusion, and the maintenance of spasm may have been an expression of shock in such cases. There was an obvious loss of blood and plasma through the capillary walls sufficient to account for shock.

In summarizing the pattern of behavior of the smaller vessels following arterial occlusion, it can be said that both the artery and vein respond by a marked degree of spasm. The reactive hyperemia following release of an arterial occlusion is not reflected in the caliber of the small arteries. On the contrary, the small arteries may actually be in a state of spasm while the tissues grossly are more red than normal. This would indicate that the increased blood flow in the larger vessels, as reported by others, and the dilatation of the capillaries during the period of reactive hyperemia are compensated for in part by spasm in the precapillary arterial bed. This is apparently protective in nature. Abramson has termed

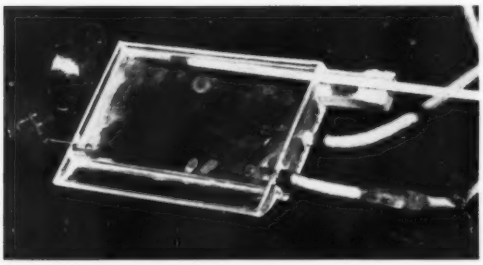

Fig. 4. a, above, Detail of double layer lucite tray. Upper chamber holds mesentery submersed in circulating mammalian Ringer's solution. Thermometer indicates temperature of Ringer's solution. Water circulates through lower chamber. Inlets on one side; outlets on the other. b, Detail of mesentery in place on lucite tray. Intestine held in nonstretched position.

the arterioles "the stopcocks of the capillary vessels." Thus, large vessels, small vessels, and capillaries may each behave differently in response to a given lesion.

STRANGULATION OCCLUSIONS

Having established a fairly definite pattern of response in the small vessels following main-stem vascular occlusions in the mesenteric vessels, we were interested in whether the more peripheral occlusions, such as occurred in strangulations would give similar responses. Consequently, in 12 dogs venous type strangulations were made with binding tape involving an intestinal loop of sufficient length to give us a satisfactory microscopic view of the involved portion of the mesentery. This was usually some 15 or 18 inches of bowel. Because of the very nature of this type of occlusion, it was not possible to duplicate exactly the same lesion in each animal. Nonetheless, our findings were rather constant.

Vasospasm distal to the occlusion followed most strangulations but differed somewhat in character from that following main-stem occlusions. In the strangulations vasospasm was not as severe and developed more slowly, while thrombosis developed more rapidly than in the main-stem occlusions. The thrombosis usually followed very closely the first signs of vasospasm. In 3 instances thrombosis actually occurred in some vessels before spasm became evident in others. In such cases the larger, patent vessels decreased in caliber.

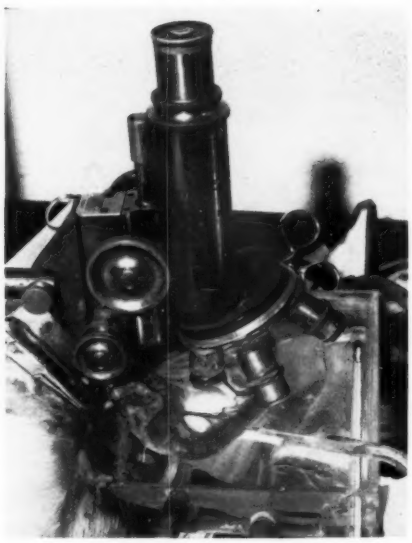

Fig. 4. b.

Upon release of the strangulation, residual vasospasm was observed in the still patent small arteries. Once thrombosis of a vessel was complete, the vessel reacted no longer whether the bowel regained viability or not.

DISCUSSION

In measuring the responses of small vessels to occlusive lesions by means of direct micrometry, we have uncovered certain behavior patterns, which until now have not been measured by direct observation. Certain features, however, have been known for some time. For example, arterial vasospasm following venous occlusion was first reported in a clinical study by Trémolières and Véran in 1929, in which these authors described a case of arterial obliteration in the leg occurring in the course of thrombophlebitis. Following this report a number of similar articles appeared in the French (4, 5, 6, 13, 15, 16, 40), Italian (39, 44), and German (24, 25) literature. In some instances of thrombophlebitis the vasospasm was so marked that the condition was originally considered to be one of arterial embolism, and actual gangrene has been known to occur (7, 42). However, the mechanism was not well understood. In 1934,

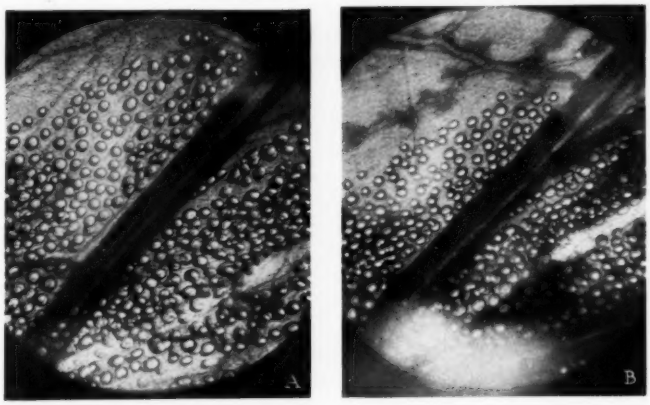

Fig. 5. Venous occlusion. A, Control appearance of vein (left) and artery. B, After 45 minutes venous main-stem occlusion, artery is narrower and vein is wider than control. Note petechiae from capillary in upper portion of photograph. Magnification × 25.

Leriche and Kunlin (28) postulated the existence of an inflammatory exudate about the area of thrombophlebitis which they claimed threw the adjacent artery into contraction, and this in turn set up a peripheral vasoconstriction. The process was clarified by the experimental work of DeBakey, Burch, and Ochsner, reported in 1939. These authors found that chemical femoroiliac thrombophlebitis produced a marked diminution in the volume of peripheral pulsations in the dog. Interruption of the nerve pathways by lumbar sympathectomy abolished this effect. This indicated that vasoconstrictor impulses arose in the thrombotic vein and were transmitted to the arteries by way of the ganglia. These authors also demonstrated a diminution in pulsations following simple ligation of the main vein, making it unnecessary to implicate an inflammatory exudate as the irritant in the acute stage. By injecting irritating chemicals about the artery, they showed that the same

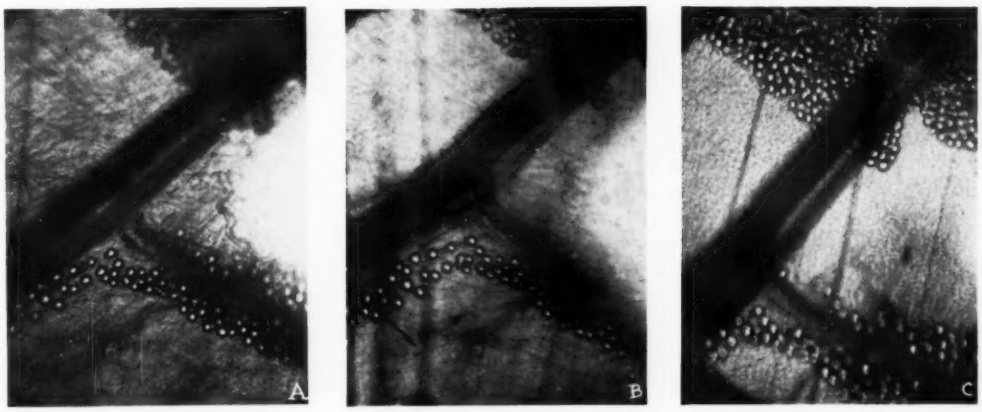

Fig. 6. Venous occlusion. A, Control appearance of vein (left) and artery. B, After 1 hour 15 minutes venous main-stem occlusion, showing marked spasm of artery while vein is dilated. C, Ten minutes after release of venous occlusion, showing residual spasm in artery. Magnification × 25.

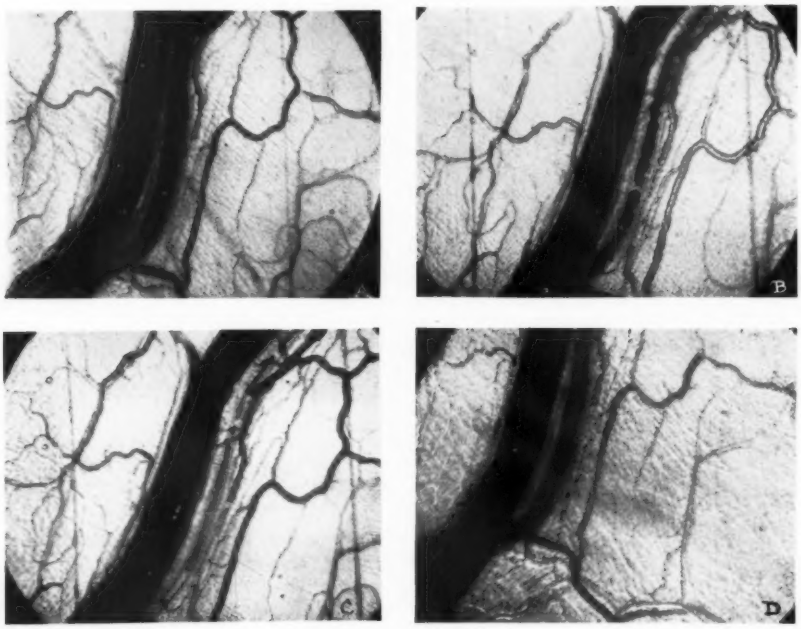

Fig. 7. Arterial occlusion. A, Control appearance of vein and artery. B, Appearance after 20 minutes of arterial occlusion. Note sludge formation of cells in artery and segmentation of column of blood. Capillaries are relatively empty but not unduly narrowed. C, Appearance after 30 minutes of arterial occlusion. Artery is in marked spasm. Vein in moderate spasm. Capillaries are now thrombosed. D, Appearance 5 minutes after release of arterial occlusion. Note residual spasm in artery. This spasm persists throughout the period of reactive hyperemia. Magnification × 25.

pattern, to an exaggerated degree, occurs once an exudate is present. Our experiments on venous occlusion confirm those of DeBakey, Burch, and Ochsner.

Leriche's main contribution in this field was his contention that the edema following venous obstruction is largely due to peripheral vasospasm and his discovery that sympathetic procaine block relieves the edema (26, 27, 29). McMasters and Parsons in 1938 substantiated this point of view by showing that in the absence of arteriolar pulsations the lymph flow was slow, while in the presence of pulsations, the flow was rapid. Ochsner and DeBakey (38) in 1940 emphasized the vasospastic element in venous occlusive disease and popularized Leriche's work by recommending sympathetic procaine block for the relief of edema following thrombophlebitis.

Our studies have uncovered an additional feature of the pattern which appears to have an important bearing on the recoverability of strangulated intestine and may also be of consequence in other occlusive lesions. This consists of a state of vasospasm which remains after release of the occlusion. We have termed this phenomenon *residual vasospasm*. It has been shown in this laboratory (23) that residual arterial vasospasm following release of a venous strangulation of the intestine may prevent recovery of an otherwise viable intestinal loop.

We found that spasm resulting from a main-stem occlusion, be it arterial or venous, depends primarily upon the completeness of the occlusion. Whenever the expected reactions in the small vessels did not occur, this was due either to destruction of the nerve filaments about the vein by dissection, or to an accessory vessel arising just proximal to the clamp. If these accessory vessels were ligated and the clamp reapplied in the same place, the usual

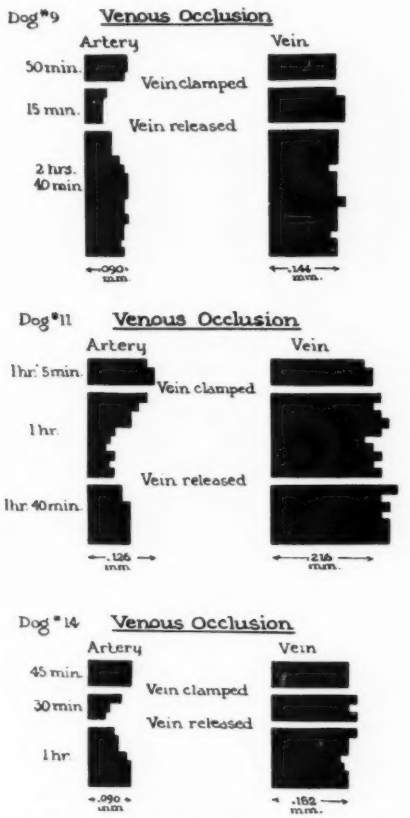

Fig. 8. Graphs showing typical patterns of behavior of small arteries and veins in main-stem venous occlusion. During venous occlusion there is spasm of the artery and moderate dilatation of the vein with residual arterial spasm after release of the occlusion.

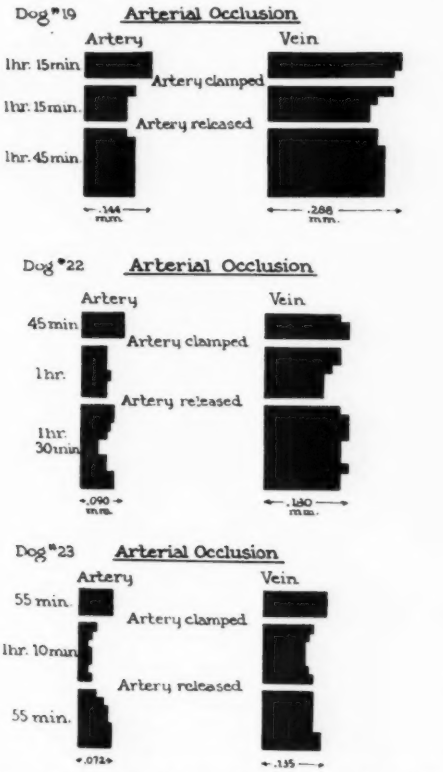

Fig. 9. Graphs showing typical patterns of behavior of small arteries and veins in main-stem arterial occlusion. During arterial occlusion there is spasm of the artery and vein with residual spasm following release of the occlusion even in the presence of gross reactive hyperemia.

pattern of vasospastic responses occurred. Though the degree of spasm was not always the same, the pattern was fairly constant.

On this basis, it may be possible to explain the inconstant clinical reports regarding the temperature of an extremity following venous thrombosis (1). If the occlusion in the main-stem vein is complete from the beginning, the arterial spasm will be severe and the limb will be cold. If the thrombosis occurs in a section of the vessel allowing for partial venous circulation, the arterial spasm may be inconsequential or absent, in which case the limb will be warm. Such a limb may be even warmer than normal, since there is no diminution in the arterial inflow and a partial obstruction to the outflow. Thus, as far as we can postulate from our experiments, one of the crucial issues is the position of the occlusion in the vessel in relation to accessory branches.

We found, further, that capillary responses do not necessarily parallel those of the artery or vein. The small artery remains in a state of spasm long after the capillaries have become widely dilated. In venous occlusions the capillaries are dilated by distention, though not uniformly so. In arterial occlusions the capillaries contract severely, but eventually relax due to anoxia. Even after this type of relaxation the small arteries remain spastic.

Spasm of the small branches of an occluded artery has been described many times in the literature (8, 11, 31, 32, 35, 41). Our observations not only confirmed the clinical findings reported by others, but we found that residual spasm occurs in the small arteries in the presence of reactive hyperemia. Our explanation, as stated, rests on the fact that there is a difference in response under certain circumstances by each of the three portions of the vascular tree—the main stem, the small vessel, and the capillary.

Observations of the intravascular blood during the various stages of arterial occlusion have brought up certain speculations regarding the associated phenomena in clinical occlusive arterial disease. We have observed that venous spasm invariably accompanies arterial spasm in arterial occlusion. The streams in both the arterial and venous systems become retarded. Clump formation, or the agglutination of erythrocytes, occurs in both the arteries and veins. It would seem that here is an explanation for the thrombotic phenomenon so often seen in the venous system accompanying arterial occlusive disease. The segmental type of venous thrombosis which often is an integral part of Buerger's disease could thus be explained on the basis of clump formation in the smaller radicals of any given venous segment propagating to build a large thrombus which finally occludes the regional segment of a large vein.

In venous type strangulation occlusions, we found that thrombosis played a more important role than in the main-stem vascular occlusions. Spasm of the small artery occurred, as it did in the main-stem occlusions, but when the small vessel became occluded by a thrombus, it no longer reacted. Residual spasm was observed upon release of the strangulation, as previously reported (23). When thrombosis occurred during residual spasm, the spasm remained whether the bowel regained viability or not.

We are now conducting experiments utilizing various therapeutic agents, such as sympathetic nerve section, and certain drugs in an attempt to observe directly the effects of such agents on the caliber of the small vessels and the state of the blood in the various stages of occlusive lesions. These findings will be reported in another communication.

CONCLUSIONS

1. Vasospasm generally accompanies main-stem vascular occlusions.

2. In venous occlusion there is a marked arterial spasm (decreased caliber) and a venous dilatation (increased caliber).

3. Following release of venous occlusions, the artery remains in a state of moderate spasm for a considerable period of time. We have termed this phenomenon *residual spasm*.

4. In arterial occlusion there is a marked arterial spasm and a concomitant venous spasm.

5. Following release of arterial occlusions, grossly visible reactive hyperemia occurs, but during this state the precapillary artery remains in spasm.

6. "Sludge" formation (Kniseley) is seen in the smaller vessels during both arterial and venous occlusions. Minute thrombi form easily in the spastic vein during arterial occlusion and may propagate, thus accounting for segmental venous thrombosis in arterial occlusive disease. This observation makes it unnecessary to postulate the presence of periarterial inflammation as a venous irritant in the production of venous thrombosis.

7. Reactivity in a small vessel becomes arrested once the vessel is thrombosed.

8. The importance of vasospasm in the phenomena accompanying vascular occlusions in general is emphasized.

REFERENCES

1. Abramson, D. I. Vascular Responses in the Extremities of Man in Health and Disease. Chicago: University of Chicago Press, 1944.
2. Allen, E. V., Barker, N. W., and Hines, E. A. Jr. Peripheral Vascular Diseases. Philadelphia: W. B. Saunders Co., 1947.
3. Allen, E. V., and Crisler, G. R. J. Clin. Invest., 1937, 16: 649.
4. Audier, M. Progr. méd., May 4, 1935, pp. 729-738.
5. Idem. Paris méd. 1936, 1: 384.
6. Audier, M., and Haimovici, H. Presse méd., 1938, 46: 1043.
7. Bergeret, A., Guillaume, A. C., and De Larne, J. Ann. anat. path. Par., 1932, 9: 536.
8. Collins, D. C. Am. J. Surg., 1936, 33: 210.
9. DeBakey, M., Burch, G. E., and Ochsner, A. Proc. Soc. Exp. Biol., N.Y., 1939, 41: 585-590.
10. Denk, W. Münch. med. Wschr., 1934, 81: 437.
11. de Takats, G., Beck, W. C., and Fenn, G. K. Surgery, 1939, 6: 339.

12. EICHNA, L. W., and WILKINS, R. W. Bull. Johns Hopkins Hosp., 1941, 68: 450.
13. FONTAINE, R., ISRAEL, L., and SOUSA PEREIRA. J. chir. Par., 1936, 47: 926.
14. GOSSET, A., BERTRAND, I., and PATEL, J. Ann. anat. path., Par., 1932, 9: 841.
15. GRÉGOIRE, R. Presse méd., 1938, 46: 1313.
16. Idem. Mém. Acad. chir., Par., 1938, 64: 363.
17. HOMANS, J. N. England J. M., 1942, 226: 917-922; 1942, 226: 951-955.
18. KNISELEY, M. H. Anat. Rec., 1938, 71: 503.
19. Ibid., 1936, 64: 499.
20. KNISELEY, M. H., ELIOT, T. S., and BLOCH, E. H. Arch. Surg. 1945, 51: 220-236.
21. KROGH, A. The Anatomy and Physiology of the Capillaries. 2d ed. New Haven: Yale University Press, 1929.
22. LAUFMAN, H. Surg. Gyn. Obst., 1942, 74 (2a): 479.
23. LAUFMAN, H., and METHOD, H. Surg. Gyn. Obst., 1947, 85: 675-685.
24. LÄWEN, A. Zbl. Chir., 1934, 61: 1681.
25. Idem. Arch. klin. Chir., 1937, 189: 53.
26. LERICHE, RENÉ. J. Internat. Chir., 1938, 3: 585-598.
27. LERICHE, R., and JUNG, A. J. chir., Par., 1931, 37: 481-495.
28. LERICHE, R., and KUNLIN, J. Presse méd. 1934, 42: 1481.
29. LERICHE, R., and WERQUIN, M. G. Lancet, Lond., 1940, 2: 296.
30. LEWIS, T. The Blood Vessels of the Human Skin and Their Responses. London: Shaw & Sons, Ltd., 1926.
31. LINDNER, E., and KATZ, L. N. J. Pharm. Exp. Ther., 1931, 72: 306.
32. MCEACHERN, C. G., SMITH, F. H., and MANNING, G. W. Am. Heart J., 1941, 21: 25.
33. MCKECHNIE, R. E., and ALLEN, E. V. Proc. Mayo Clin., 1935, 10: 678.
34. MCMASTERS, R. J., and PARSONS, P. D. J. Exp. M. 1938, 68: 353.
35. MULVIHILL, D. A., and HARVEY, S. C. J. Clin. Invest., 1931, 10: 423.
36. NICOLE, R. Schweiz. med. Wschr., 1935, 65: 675.
37. OCHSNER, A. Surg. Gyn. Obst., 1947, 84: 659-664.
38. OCHSNER, A., and DEBAKEY, M. J.Am.M.Ass., 1940, 114: 117-124.
39. PAMPARI, D. Policlinico, 1938, 45: 470.
40. PESNEL, P. Sem. hôp. Paris, 1938, 14: 378.
41. SCUPHAM, G. W., DE TAKATS, G., VAN DELLEN, T. R., and BECK, W. C. Arch. Int. M., 1938, 62: 482.
42. TILLEY, J. H. Am. J. Obst., 1938, 36: 157.
43. TRÉMOLIÈRES, F., and VÉRAN, P. Bull. méd. Paris, 1929, 43: 1101.
44. UGGERI, C., and MASSONE, A. Arch. ital. chir., 1938, 49: 429.

THE USE OF THE MOE PLATE IN THE TREATMENT OF INTERTROCHANTERIC FRACTURES

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OPEN reduction with internal fixation of intertrochanteric fractures of the femur has become an accepted procedure only within the past few years. As a rule this type of fracture yields readily to so-called conservative methods of treatment. There is, however, a definite incidence of these fractures in elderly patients who are poor medical and surgical risks. This fact has tended to be overlooked in the large amount of literature occasioned by the use of the Smith-Petersen triflanged nail for fractures of the neck of the femur. It is the purpose of this paper to present the use of a new type of internal fixation apparatus, called the Moe plate. This plate was devised by Dr. John H. Moe of Minneapolis and to the best of our knowledge has not previously been described in the literature. During the past year the Moe plate has been used in the treatment of intertrochanteric fractures at the Boston City Hospital. Because of the highly satisfactory results obtained in this series of cases, the following report is submitted.

In the past, many methods of immobilization have been used to treat intertrochanteric fractures of the femur. These include abduction spica casts, well-leg traction, Russell's traction, the Hodgen splint, just to mention a few. But it has been pointed out by several (1, 8, 13, 22, 25, 26) that the complications which arise out of such treatment greatly increase morbidity and mortality in the aged. It is for these reasons that open reduction and internal fixation have been advocated for the treatment of this type of fracture (6, 9, 13, 22).

In favor of the operative therapy for intertrochanteric fractures, it has been pointed out that the incidence of these fractures is high, varying from 47.8 (25) to 64 per cent (24) of hip fractures, and Morris found them to be four times as frequent as fractures of the femoral neck. Thus, these fractures account for a considerable number of all hip fractures and are a serious problem in the older age groups. In addition, in older age groups intertrochanteric fractures occur more often than those of the femoral neck. In several series (2, 10, 13, 14, 16, 17, 21, 23, 26) reported in the literature the average age of patients with intertrochanteric fractures is 70.39 years, whereas that of patients with femoral neck fractures is 65.1 years (13, 26).

Other factors which contribute to the greater severity of intertrochanteric fractures are the greater trauma usually responsible for this type of fracture, with a greater degree of shock, more hemorrhage, and more soft tissue damage than that which occurs with fractures of the femoral neck. As a result, there is usually more severe pain and a greater deformity. Another factor which contributes to the greater shock and pain is the marked degree of comminution of fragments which often occurs in intertrochanteric fractures. This comminution, as seen at the time of operation, is frequently much greater than is apparent by x-ray examination.

Most of the conservative methods of treatment require prolonged periods of immobilization and bed rest. Such procedures involve a high incidence of hypostatic pneumonia, decubitus ulcers, joint stiffness, incontinence, mental deterioration, thrombophlebitis, muscular wasting, and general debility. Early ambulation, especially of the aged, is currently much emphasized. Additionally there is a shortage of trained nurses. Hence a method by which nursing care can be reduced to a minimum and aged patients can be made ambulatory on crutches at an early period in their illness is much to be desired. This can be accomplished by open reduction and internal fixation of these fractures.

It has been shown (6, 9, 21, 22) that open reduction leads to freedom from pain almost

immediately after operation. Early crutch ambulation is possible, the patient is allowed more freedom in bed, and there is a reduction in the total amount of hospitalization. Joint stiffness, limb atrophy, and bed sores are minimal or absent. Chiefly, there is a decrease in mortality and morbidity. In the past 8 years, several methods of internal fixation for intertrochanteric fractures have been reported (3, 6, 7, 8, 9, 10, 11, 13, 15, 16, 17, 18, 20, 22, 25, 27, 28), all with similar results in general, and it is beyond the scope of this paper to report these methods.

In order to maintain reduction of an intertrochanteric fracture it is necessary to immobilize not only the fracture site but also the proximal and distal fragments. Because the neck of the femur makes an average angle of 127 degrees with the shaft, any form of fixation which transfixes only the fracture site is not sufficient in most cases to overcome the muscle pull and prevent a coxa vara deformity. This difficulty is met in most devices by a plate which attaches to the upper end of the femoral shaft. It is incorporated into the mechanism immobilizing the fracture site, so as to counteract the muscle pull and to prevent the deformity. In some devices this is accomplished by a single piece (3, 8, 11, 15, 16, 17), in others by a combination of devices (7, 9, 18, 22, 25, 27, 28). The Moe plate, which is the subject of this report, is a single plate, bent to fit over the greater trochanter in its proximal portion and prolonged into a plate to fit the femoral shaft in its distal portion (Fig. 1).

The Moe plate is constructed of stainless steel of the S.M.O. 18–8 group and has the shape of a question mark, the curved portion being that portion which is molded to fit over the greater trochanter. The plate has been placed against the femur in several skeletons and has been found to fit without any change being necessary. The size of the plate is determined largely by the straight prolongation which fits over the shaft of the femur and which is drilled to accommodate from 3 to 5 screws. Before operation, the size of the plate to be used can be gauged roughly by placing it against the x-ray film, with due allowance for distortion, and this method has been found to be quite satisfactory as the distortion encountered is seldom great enough to cause difficulty.

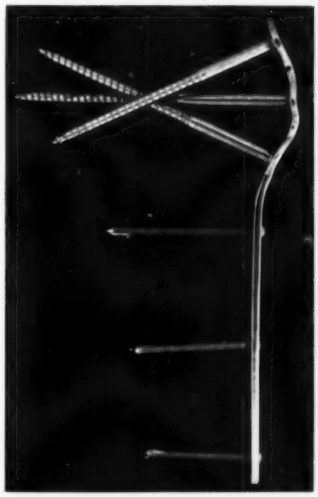

Fig. 1. The Moe plate.

The curved portion of the Moe plate forms the arc of a circle with a radius of approximately 4.5 centimeters. As shown in Figure 1, it is perforated by three screw holes, placed 2 centimeters apart. These holes are countersunk for the head of the Venable wood type hip screws which are used for this portion of the plate. Thus allowance also is made for slight variations in the angle at which the screws are inserted, depending upon the conditions encountered at operation. At first glance, one would think that the three screws, which are inserted across the fracture site and into the cancellous bone of the head and neck of the femur, would abut against one another, but in actual practice this problem is seldom encountered. If encountered, it is easily remedied by altering the angle of insertion of the offending screw. In addition, the use of the three large screws provides fixation across the fracture site in three planes and prevents deformity due to rotation, besides adequately maintaining reduction.

The straight prolongation of the Moe plate has a varying number of holes as previously mentioned. Stainless steel screws of the Sher-

Fig. 2.

Fig. 3.

Figs. 2 and 3. Anteroposterior and lateral roentgenograms of a comminuted fracture, a condition which is amenable to Moe plating

Fig. 4.

Fig. 5.

Figs. 4 and 5. Postoperative results. Because of severe comminution, a third hip screw could not be used. A slight degree of varus deformity is apparent by x-ray examination.

man type are used usually to apply this portion of the plate in the usual manner. One thing that has been noted in this study is that the first or upper hole of the plate portion lies opposite the lesser trochanter, and for this reason a longer screw is necessary here than for the rest of the shaft. It is to be emphasized that the screws used should be of the S.M.O. 18–8 group of stainless steel in order to avoid electrolytic osteitis

Upon admission to the hospital, and after roentgenograms have been taken to determine the type of fracture, the patient is placed in traction to minimize pain and shock. If operation is contemplated, simple Buck's extension or Russell's traction is usually sufficient. The type of preparation depends upon the preference of the surgeon, some preferring a skin preparation of 2 days, others of 1 day.

The optimum time of operation following injury is controversial. There are some operators (8, 9, 25) who believe that these patients should be treated as emergency cases. Other surgeons (14, 27) believe that operation should not be undertaken for 3 to 4 days during which time it can be determined whether or not the patient will survive the initial shock. In the 30 cases presented in this report the latter method of treatment was used. It is the opinion of the authors that these patients should be operated upon as soon as possible after the initial shock has been combatted by the usual methods. Preoperative care should be directed toward improving the general health of the patient.

In the operating room, the patient is prepared and draped in the usual manner with the involved extremity draped free. Again, the type of incision used depends upon the surgeon's preference. The two types used in this series were the straight lateral incision, and later the inverted J-shaped incision (Watson-Jones), as the latter was felt to provide a greater and easier exposure in the trochanteric region. The incision is made through the deeper layers, through the tensor fascia femoris and vastus lateralis muscles to bone. The periosteum is incised and elevated only enough to accommodate the plate. The exposure is made adequate to visualize the fracture line in order to aid in the reduction. If the exposure is carried too far posteriorly below the greater trochanter, troublesome bleeding may be encountered from large tributaries of the deep branch of the medial circumflex femoral artery.

When the exposure is adequate, the fracture is reduced by traction and manipulation. If the fracture line is exposed, the accuracy of reduction can be checked visually. If desired,

Fig. 6.

Fig. 7.

Fig. 8.

Figs. 6, 7, and 8. Postoperative x-ray films of Moe plating with either the 2 or 3 hip screw method.

it may be verified by x-ray examination. One of the features of the Moe plate is that it may be applied without x-ray control, which decreases the operating time considerably. In all the cases in this series operation was carried out without x-ray control, but in the hands of inexperienced operators the use of x-ray control is desirable. While the majority of intertrochanteric fractures are reduced by traction and internal rotation combined with abduction, it was noted that several in this series required external rotation in order to effect reduction. That this was the case could not be determined from the preoperative roentgenograms.

While the reduction is maintained by an assistant or by mechanical means, the plate is placed against the shaft and greater trochanter, and as the fit is usually satisfactory further shaping of the Moe plate is not necessary. The outer cortex of the greater trochanter is penetrated with a large size drill point in order to allow for easier introduction of the large Venable hip screws. These screws are furnished in several sizes and their length is determined roughly by comparison with the preoperative x-ray films. The direction of the screw is determined by the angle of the femoral neck upon the shaft and can be gauged by a probe or clamp inserted over the anterior surface of the capsule. One of the large screws, usually the longest of the three, is then inserted in the middle or lower hole of the curved portion. Following this, the plate is fixed to the shaft with a screw through the first hole of the straight portion of the plate. This prevents rotation of the plate while the remaining screws are placed and also fixes the fracture. The remaining screws are then inserted. X-ray examination will disclose whether or not the large screws are too long. If any screws project into the acetabulum they should be removed and replaced by shorter ones.

In the markedly comminuted type of intertrochanteric fracture, it is not always possible to align all the small fragments, but the major fragments can be held without difficulty by the Moe plate as illustrated in Figure 2. It is in these comminuted fractures which cannot be held with other devices that the Moe plate shows its greatest usefulness. In several of the cases in this series, the original plan was to use a different fixation device, but because of the comminution, the Moe plate was the only de-

Fig. 9. Coxa vara deformity.

vice that could be used. The cortex in this type of fracture is usually too fragmented to use nails and single large elements, and the lines of fracture too diverse for other devices to hold. The Moe plate, however, can be applied and used to maintain the reduction, as the curved element depends for its holding power on the grip of the screws in the cancellous bone of the neck and head of the femur proximal to the fracture site. In the presence of marked comminution it is not always possible to use three large Venable hip screws, especially at the uppermost screw hole. In these cases, with the use of a special washer provided with the plate, a Sherman type screw can be used to aid in the fixation. In instances where there are complicating subcapitellar fractures in addition to comminution in the trochanteric region, use of the Moe plate was not attempted, as osteotomy offers the only solution as a rule.

After the plate is applied, the solidity of fixation can be tested by moving the hip. The femur will move as one piece if reduction is maintained. The wound is then closed in layers and a dressing applied.

The after care is the same as for any open reduction of hip fractures. It was found that the use of Buck's extension with 5 to 10 pounds traction for 2 to 3 days postoperatively reduced the degree of postoperative pain, probably due to the relief of muscle spasm. The patients are made ambulatory on crutches as soon as possible after operation, usually after learning to get along in a walker first. The time at which patients can be made ambulatory on crutches depends upon the individual's ability and co-operation, provided the patient's general condition does not preclude ambulation. Crutches are used until roentgenograms show that union has taken place, usually in 10 to 16 weeks.

The chief difficulty with either conservative measures or internal fixation including the Moe plate is the frequent coxa vara deformities which may result from too early weight bearing, inadequate reduction, or the tendency of patients to bear weight too early in spite of instructions to the contrary (Fig. 9).

This report is concerned with the presentation of 30 unselected cases of intertrochanteric fractures of the femur which were treated by open reduction and the use of the Moe plate. The patients were treated on the orthopedic and general surgical wards of the Boston City Hospital during the period from July 1, 1946 to August 30, 1947. This figure does not represent the total number for that period, but only those for which there is sufficient data and follow-up from which conclusions can be formed. The operations were performed by the resident staff and visiting surgeons on those services.

The majority of the 30 patients were charity cases and therefore came from a social status in which poor general health and nutrition was the rule rather than the exception. Consequently, the mortality rate in the past has been rather high, about 34 per cent (5). In this series, there were 5 postoperative deaths or a mortality rate of 16.67 per cent, a figure which is comparable to that of other reported series of operative cases. These deaths will be taken up in more detail later.

The average age of the patients in this series was 66.7 years, which is slightly lower than that of other reported series. This may be explained in part by the fact that in the city of Boston in the majority of accident cases the patients are brought to the Boston City Hospital regardless of whether they are residents or not, and a large percentage of the total seem to be in the younger age groups.

The mode of accident was usually the same in all cases of this series, namely a slip and a fall, either in the home or on the street. The preoperative methods of traction used were varied, depending upon the surgeon's or resident's preference. Fourteen patients were treated with Russell's traction preoperatively, 9 by simple Buck's extension, 3 with balanced suspension traction and skeletal traction through the proximal tibia, and 1, first by Buck's, and then by Russell's traction. In 3 cases the method used is unknown. The use of traction in this series preoperatively was to alleviate pain and help to make the patient more comfortable.

The interval between the day of admission and the day of operation varied considerably —from 3 days to a maximum of 51 days. The average interval was 12.8 days. The discrep-

ancy between minimum and maximum interval may be accounted for by the fact that operation was performed as soon as possible after admission on the orthopedic service with the 3 day interval being considered necessary at the time to allow the patient to recover from the initial shock and trauma. On the other hand, on the general surgical services operation was usually delayed for one reason or another. In addition, several patients on the general surgical services who, after conservative treatment, showed marked deterioration after 3 to 4 weeks, were transferred to the orthopedic service for operation. These were cases in which the illness threatened to be terminal if the patient did not soon become ambulatory. As a result, operation was carried out at a late date on several patients as a lifesaving measure which was not always successful. In 6 of these cases so transferred, the reason was given as general debility and decubitus ulcers, and the interval between admission and operation in these cases was 31, 24, 51, 23, and 24 days respectively.

It is interesting to note the number of hospital days required for this series of patients. The average hospital stay, exclusive of deaths, was 51.6 days. This is longer than is reported by Morris whose patients had an average hospitalization of 29.5 days, and of Harmon whose patients averaged 40 days, but it is less than that reported for patients treated by traction (16, 24), and less than the average of 62.3 days reported by Johnson for the hanging cast therapy. Part of the length of hospitalization in this series is due to the long interval between admission and operation as explained in a previous paragraph. Another factor which contributed to the prolonged hospitalization was the fact that a number of the patients were destitute and had to be kept in the hospital until the social service department could arrange for placement in a convalescent home or chronic care hospital. This protracted care tended to elevate the general average as 2 cases of this sort were hospitalized for 114 and 112 days respectively. The shortest hospitalization was 21 days which occurred with 3 patients. As reported by Leydig and Brookes the average hospital stay for intertrochanteric fractures was 84.7 days for charity patients and 56.4 days for private patients. This is an important and pertinent comparison when total hospitalization is discussed, although their series consisted of nonoperative cases. Lucas and Varney reported an average hospitalization of 45 days for operative cases, and although Morris' figure for total hospitalization was low, he believed that this figure was increased because many of his patients had inadequate facilities for home care. We believe that in the absence of social service problems it is reasonable to assume that operative treatment will greatly reduce the number of hospital days required for the treatment of this type of fracture.

In any series of operative cases the presence or absence of sepsis should be noted. In our series there was 1 case of a superficial wound infection which responded to local therapy and might well have been due to the handling of the wound beneath the dressing by the patient. Many of the patients received penicillin as a postoperative routine and this may have been a factor in the low incidence of wound infection.

As would be expected in any series which deals with the older age groups, there were several other complications which should be noted. Bronchopneumonia occurred in 5 cases after operation, but this disease was nonfatal in all and responded well to treatment. In 3 cases, a low-grade fever occurred postoperatively for several days for which no adequate explanation could be found. As most of the patients in this series were checked routinely each day for evidence of thrombophlebitis and phlebothrombosis, this mechanism as a cause of the fever can probably, but not with absolute certainty, be eliminated. Cardiac decompensation occurred in 1 patient after operation, superficial phlebitis in another, and 1 patient had persistent ankle edema of the affected limb following surgery.

Table I summarizes other aspects which were considered in this series. We set up a rather arbitrary classification for these cases before and after operation. Those classified as "good" include the patients who had no complicating injuries or medical diseases, and who were active prior to injury. The "fair" group includes patients with such conditions

TABLE I.—STATISTICAL BREAKDOWN, 30 CASES INTERTROCHANTERIC FRACTURE

Technical surgical difficulties		General condition preoperative		General condition postoperative		Special medication		Deaths	
No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
3	10	Good—15	50	Good—20	66.67	Penicillin—17	56.7	5	16.67
		Fair— 6	20	Fair— 5	16.67	No penicillin 13	43.3		
		Poor— 9	30	Poor— 5	16.67	Transfusions† 16	53		
		Rarely shock*							

*1 case incipient shock on operating table
†Either during operation or immediately postoperative

as mild or moderate cardiac decompensation, secondary anemias, severe arteriosclerosis, general debility, severe malnutrition, mild hemiplegias, diabetes of moderate severity, moderately poor renal function, etc. For those who did not fit in the above categories, the classification of "poor" was made, and includes patients with complicating medical conditions of a severe nature. It is the latter group that accounts for the mortality rate of 16.67 per cent, which is a figure consistent with the average mortality rate of 17.09 per cent of several reported series of operative cases (9, 11, 13, 16, 17, 21, 25, 26).

Although only a little over 50 per cent of the patients in this series were treated with penicillin for 24 hours before operation, we are inclined at the present time to treat all bone repairs with this drug before operation. In the only case in which superficial wound sepsis occurred, the patient received 40,000 units of penicillin every 3 hours for 1 day prior to surgery.

Transfusions of 500 cubic centimeters of whole blood were given to 15 patients either during or immediately following surgery, and 1 additional patient required a total of 1,000 cubic centimeters of whole blood to combat shock. The remaining patients were given intravenous fluids during the operative procedure. At the present time, all patients, unless robust, are given at least 1 transfusion during the operative procedure which enables them to tolerate the surgery much better.

Technical surgical difficulties were few. Of the 30 cases, only 3 patients or 10 per cent presented problems of any marked degree. In 1 case, the operative procedure was difficult because of severe comminution at the fracture site, and there was some delay in securing reduction and proper alignment of the fragments. The other 2 cases were problematical as 3 or more weeks had elapsed before surgery was undertaken for reasons previously mentioned. In 1 of these, a fair amount of osteoid tissue in the midst of a large hematoma was located between the fragments and this had to be evacuated before definitive surgery could be carried out. The third and last case which presented any difficulty was that of a patient who had been treated conservatively for a period of 7 weeks without the appearance of any definite callus by x-ray examination. This patient was transferred from a general surgical service to the orthopedic service for surgery because of large decubitus ulcers and progressive mental and physical deterioration. In this instance, when the fracture site was exposed, attempts to abduct the femoral shaft were futile until the iliopsoas and adductor muscle groups were freed. Therefore, in a review of this series of cases, it is apparent that the only real obstacle one may expect to meet is a difficult reduction and prolonged operating time due to comminution of the fragments. This applies only to those cases wherein surgery is performed within a few days after injury. As previously stated, no technical surgical difficulties were met in applying the Moe plate once the fracture had been reduced.

In the analysis of the 5 patients who died, all were poor surgical risks. S.C., B.C.H. No. 1237213, was a 90 year old female who had been treated conservatively and had received intensive medical therapy for 16 days prior to operation. As her condition began to deterio-

TABLE II.—RESULTS OF FOLLOW-UP EXAMINATIONS AT END OF 6 MONTHS

Patient	Flexion		Internal and external rotation. Hip	Ankle edema	Ambulation	Shortening Inches	X-ray examination	Pain
	Hip Degrees	Knee						
1	90	45	50% normal	None	Without crutches at end of 3 mos.	½	Good callus end of 12th postoperative week	None
2	Normal	Normal	Normal	None	Without crutches at end of 3 mos.	None	Good callus 11½ weeks	None
3	80	100	10°	None	Without crutches at end of 5 mos.	1	Healed at 15 weeks	Pain in region hip joint related to damp weather
4	80	Normal	20°	None	Without crutches at end of 2½ mos.	1.5	Healed at 10 weeks	None
5	80	Normal	External rotation normal; internal rotation slightly limited	None	Without crutches at end of 3½ mos.	¼	Good callus at 7 weeks	Moderate in damp weather

rate rapidly toward the end of her second hospital week, the operation was carried out as a life-saving procedure. In spite of transfusions during operation and immediately after operation, she lapsed into shock of an irreversible nature and died 2 hours after the operation. In this case, one might argue that it would have been better to let nature take her usual course, but as the situation of the patient was desperate, it was felt justifiable to take the risk. The other 4 deaths were among patients who had poor cardiac reserve and their deaths were chiefly cardiac in etiology. M.P., B.C.H. No. 1215783, was a 64 year old female who died of a terminal cerebrovascular accident and complicating bronchopneumonia. M.F., B.C.H. No. 1228571, was a 73 year old female whose death was due to cardiac decompensation and bronchopneumonia 5 days after operation. Complicating diseases in this patient were arteriosclerotic and hypertensive heart disease and mild diabetes. L.G., B.C.H. No. 1225408, was a 75 year old female who died 23 days after operation because of cardiac decompensation and severe diabetes. C.K., B.C.H. No. 1240252, was a 75 year old female who died of cardiac decompensation and arteriosclerotic heart disease 55 days after operation with a further complication of bronchopneumonia. It is our belief that the latter 4 deaths could not have been avoided due to the patients' extremely poor cardiac reserve, and that in all probability the results without surgery would have been equally disastrous.

Of the total of 30 patients, only 5 (16.67%) or 20 per cent of the living were able to return to our follow-up for clinical evaluation. As a last resort, questionnaires were sent to all in the hope that we might be able to appraise the end-results of this method of treatment of intertrochanteric fractures. Of the total of 20 letters sent, only 11 questionnaires were filled out and returned. Four letters were "returned to sender—address unknown," and no reply was received from the remaining 5 patients. In other words, follow-up information was obtained from only 64 per cent of those patients believed living.

Table II summarizes the results of the examination in those 5 patients who were seen in the follow-up clinic. Of the 11 questionnaires received, 1 indicated that the patient had died of heart disease 10 months after discharge from the hospital. Five patients indicated that they were ambulatory without the aid of crutches, and of these 4 were using canes. All 11 patients complained of mild or moderate hip pain aggravated by damp or cold weather. None was bed-ridden, but 2 patients stated they were restricted to armchairs. Six patients complained of mild or moderate stiffness of the knee joint. Seventy per cent reported mild ankle edema which subsided with bed rest, and all but 1 patient claimed to have some limitation of hip flexion varying from 50 to 90 per cent. All the reports indicated that the patients were able to cross the injured leg over the uninjured member.

Because of its subjective nature, information acquired through questionnaires is not generally as reliable as that acquired through physical examination. However, as the patients could not, or would not, report to our follow-up clinic, we were forced to resort to this inferior method for evaluating the end-results of this procedure. The follow-up results in these cases include quite a few patients who were seen or heard from more than a year after their operation.

CONCLUSIONS

1. The Moe plate is a simple, adequate, and effective method of immobilization in the operative treatment of intertrochanteric fractures.

2. The application of the Moe plate creates a minimal amount of trauma due to the ease of application and the shortened operative time.

3. X-ray control is not necessary but can be used if desired.

4. With this method, patients can be made ambulatory on crutches shortly after operation, which is an important factor to minimize complications in the older age groups in which this type of fracture most frequently takes place.

5. The mortality rate in this series of 30 cases is 16.67 per cent, which is considerably less than that for so-called conservative methods, and the figure is consistent with that reported from other hospitals and clinics for surgically treated intertrochanteric fractures.

6. The Moe plate can be used very satisfactorily in the markedly comminuted intertrochanteric fractures in which it is not possible to maintain reduction with the other types of internal fixation thus far reported in the literature.

REFERENCES

1. Anderson, R., McKibbin, W. B., and Burgess, E. J. Bone Surg., 1943, 25: 153.
2. Bartels, W. P. J. Bone Surg., 1939, 21: 773.
3. Blount, W. P. J. Bone Surg., 1943, 25: 319.
4. Caldwell, J. A. Am. J. Surg., 1943, 59: 370.
5. Carroll, John. Personal communication to the authors.
6. Casberg, M. A. Surg. Gyn. Obst., 1941, 72: 772.
7. Cleary, E. W., and Morrison, G. M. J. Bone Surg., 1940, 22: 125.
8. Compere, E. L. Mississippi Valley M. J., 1945, 67: 13.
9. Harmon, P. H. J. Bone Surg., 1945, 27: 128.
10. Henry, M. O. Minnesota M., 1943, 26: 690.
11. Jewett, E. L. J. Bone Surg., 1941, 23: 803.
12. Johnson, M. D. Surg. Gyn. Obst., 1943, 77: 598.
13. Key, J. A. Surgery, 1939, 6: 13.
14. Leydig, S. M., and Brookes, T. P. J. Missouri M. Ass., 1940, 37: 354.
15. Lippman, K. K. J. Mount Sinai Hosp. N. York, 1941, 7: 459.
16. Lucas, D. B., and Varney, J. H. West. J. Surg., 1943, 51: 283.
17. McKee, G. K. Lancet, Lond., 1944, 1: 143.
18. McLaughlin, H. L. Am. J. Surg., 1947, 73: 150.
19. Moe, J. H. Personal communication to the authors.
20. Moore, A. T. Surg. Gyn. Obst., 1937, 64: 420.
21. Morris, H. D. South. M. J., 1941, 34: 571.
22. Newell, C. E. Am. J. Surg., 1947, 73: 162.
23. Posch, J. L., and Abbott, W. E. Am. J. Surg., 1945, 70: 369.
24. Siler, V. E., and Caldwell, J. A. Am. J. Surg., 1940, 47: 431.
25. Siris, I. E., and Ryan, J. D. Surg. Gyn. Obst., 1944, 78: 631.
26. Stuck, W. G. Surgery, 1944, 15: 275.
27. Thatcher, H. V. Am. J. Surg., 1943, 60: 44.
28. Thornton, L. J. M. Ass. Georgia, 1944, 33: 136.

THE EFFECTS OF VARIOUS TYPES OF SYMPATHECTOMY UPON VASOPRESSOR RESPONSES IN HYPERTENSIVE PATIENTS

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IN order to determine the effects of removing various portions of the sympathetic nervous system upon vasomotor reactions, it is necessary to measure these reactions in the same individuals both before and after surgery. Thus, if responses are shown to occur regularly before sympathectomy and are uniformly absent or altered afterward, one may conclude that the operation has been responsible for the change. For example, vasomotor reactions studied in the limbs by simultaneous measurements of blood flow and blood pressure have been found to be profoundly altered by sympathetic denervation of the parts (4).

In the splanchnic areas of human subjects vasomotor responses are difficult to measure. However, by continuously recording the ballistocardiogram along with the arterial pressure, it has been possible to distinguish the effects of changes in cardiac output from changes in peripheral resistance during vasopressor responses (5, 6). Thus, it has been shown that certain vasomotor stimuli regularly cause reactions that can be attributed only to vasomotor activity in areas other than the limbs and brain. The present study was undertaken to determine the effects of surgical removal of various portions of the sympathetic nervous system upon the vasopressor responses of patients to standard stimuli. In this way the roles played by different parts of the sympathetic nervous system in these responses have been demonstrated.

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METHODS

The subjects were patients, mainly hypertensive, selected for surgical sympathectomy of various types. They were studied before and again approximately 2 weeks after the completion of the operations. In addition, certain patients were studied at longer intervals, and of these some were studied only after operation.

Measurements were made with the patients lying quietly on the tilting ballistocardiograph (7). Arterial pressure was registered optically by a Hamilton manometer (1) attached to a needle in the brachial or femoral artery. Cardiac output was estimated with the ballistocardiograph (3), and respiration and expiratory pressure were recorded by suitable tambours placed in the same optical system. A number of sympathetic nervous stimuli were applied, including tilting into the upright position, production of reactive hyperemia in the limbs, the Valsalva experiment, the cold test, and a request to do mental arithmetic. Of these the first 3 were found to be more simple and to cause more regularly a clear-cut vasoconstrictor response. Perhaps this was due to the fact that they were all primarily blood-pressure-lowering procedures.

With the sudden stopping of a blood-pressure-lowering procedure the presence of vasoconstriction could be strikingly demonstrated by the appearance of a brief, marked hypertensive overshoot that carried the arterial pressure above control levels and could not be explained by increases in cardiac output (5, 6). The stimuli were stopped suddenly as follows: The subject, after standing upright for 5 minutes, was quickly tilted back into a horizontal position; similarly, after 15 seconds of reactive hyperemia (due to the release of circulatory arrest which had been in effect during the preceding 5 minute period) in three limbs, the

TABLE I.—VASOPRESSOR RESPONSES GRADED BEFORE AND AFTER, OR ONLY AFTER LUMBODORSAL SPLANCHNICECTOMY*

Subject	Before operation		Operation	Interval	After operation	
	Arterial pressure	Grade			Arterial pressure	Grade
Tut	210/117	II	R=D8–L2 L=D7–L1	2 weeks	175/108	Neg.
Max	160/95	II	R=D8–L1 L=D8–L1	2 weeks	120/75	Neg.
Pau	165/95	IV	R=D8–L1 L=D8–L1	2 weeks	155/85	Neg.
Far	200/95	III	R=D8–L2 L=D8–L1	2 weeks	170/90	Neg.
Ric	245/140	III	R=D7–L2 L=D8–L2	2 weeks	250/160	Neg.
Yan	280/100	III	R=D8–L1 L=D8–L1	2 weeks	275/100	Neg.
Sil	170/110	IV	R=D8–L1 L=D8–L2	2 weeks	155/115	I
Swa	180/100	II	R=D8–L1 L=D8–L2	2 weeks	145/75	Neg.
Pea	190/110	I	R=D8–L2 L=D8–L1	2 weeks	125/75	Neg.
Goo	235/135	III	R=D8–L2 L=D8–L1†	2 weeks	180/115	Neg.
Fie	170/110	II	R=D8–L1 L=D8–L1	2 weeks	135/85	Neg.
Bus	230/130	IV	R=D8–L1 L=D8–L1	2 weeks	165/95	Neg.
Fos	230/130	II	R=D8–L1 L=D7–L1	2 weeks	220/120	Neg.
Wat	215/120	I	R=D8–L1 L=D8–L1	2 weeks	150/90	Neg.
Pit	255/125	II	R=D8–L1 L=D8–L1	2 weeks	210/110	Neg.
Kon	205/110	III	R=D8–L1 L=D8–L1	2 weeks	165/90	Neg.
Nas	140/90	IV	R=D7–L1 L=D8–L1	2 weeks	140/75	Neg.
McCl	230/120	II	R=D10–L1 L=D8–L1	2 weeks	210/120	Neg.
Hur	220/125	II	R=D7–L1 L=D8–L2	2 weeks	180/110	I
Gol	230/135	II	R=D8–L2 L=D8–L1	2 months	240/145	Neg.
She	205/120‡		R=D8–L1 L=D8–L1	5 months	155/95	I
Dea	200/110‡		R=D8–L1 L=D8–L1	6 months	195/100	I
Yof	185/110‡		R=D8–L1 L=D8–L1	1 year	165/100	II
Bar	200/100‡		R=D8–L1 L=D8–L2	2 years	200/90	Neg.
Abe	185/130‡		R=D8–L3 L=D8–L3	2⅔ years	225/125	I
Dow	195/120‡		R=D8–L3 L=D8–L1	3 years	220/120	I
Ret	185/120‡		R=D8–L2 L=D8–L1	3 years	220/130	Neg.
Cha	165/100‡		R=D9–L3 L=D9–L3	4 years	135/75	I
Dem	225/125‡		R=D9–L2 L=D9–L1	4 years	230/110	Neg.
Lyn	175/130‡		R=D9–L1 L=D9–L1	4½ years	145/90	II
Sul	210/140‡		R=D9–L2 L=D9–L2	6 years	175/120	Neg.
O'L	140/9 to 180/120‡		R=D9–L1 L=D9–L1	9 years	145/85	I

*In all cases the greater splanchnic nerve was resected bilaterally from the celiac ganglion upwards throughout almost its entire extent. The variations in excision of the ganglionated trunks noted in the table are inclusive.
†A right nephrectomy had been performed elsewhere 12 weeks previously for "unilateral renal disease."
‡As reported, taken with sphygmomanometer.

circulation in them was suddenly reoccluded; or, after 10 seconds of the Valsalva maneuver (forceful expiration against a fixed resistance), the subject was asked to relax quickly and completely. Recording was then continued for at least 1 minute, and ample time for full recovery from each stimulus was allowed before applying another.

RESULTS

Responses in normally innervated subjects. Any procedure tending to lower the arterial

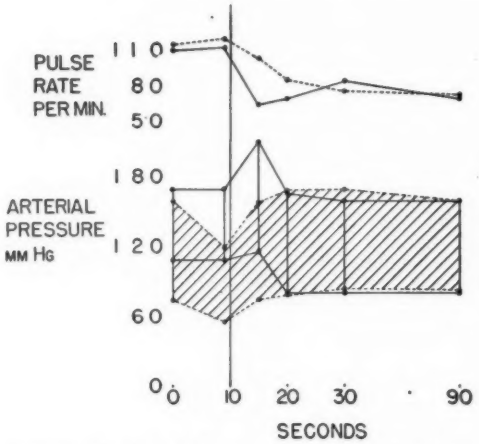

Chart 1. Showing the effects of being quickly tilted (vertical line) from the upright (75°) to the horizontal position upon pulse rate, and arterial pressure (Hamilton), of a hypertensive patient before (solid dots and lines) and after (circles and interrupted lines) a lumbodorsal sympathectomy. Before operation the subject had stood 5 minutes at the tilt-back, after operation 3 minutes.

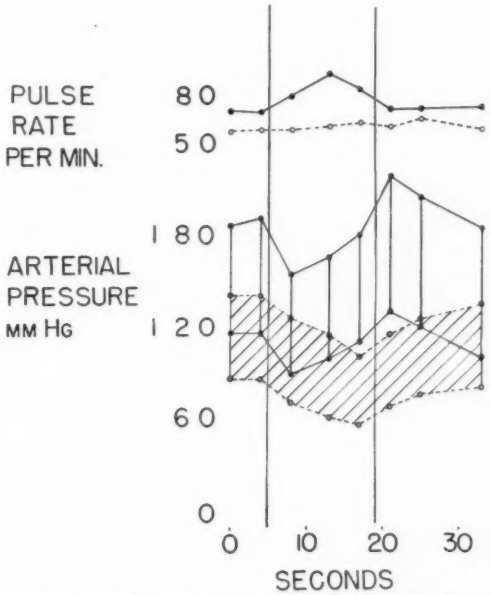

Chart 2. Showing the effects of the release (first vertical line) and reocclusion (second vertical line) of the circulation in three limbs after a preliminary 5 minutes of occlusion in a hypertensive patient before and after a total thoracic sympathectomy. Other notations as in Chart 1.

pressure evoked in normally innervated subjects a marked vasopressor response. When the stimulus was stopped the arterial pressure quickly recovered and then overshot the control levels, often reaching alarming peaks. These overshoots of arterial pressure furnished an easy and, in a given subject, a fairly reproducible measurement of the degree of vasopressor reaction to the stimuli. For example, following a quick return of the subject to the horizontal position after 5 minutes of standing, the arterial pressure quickly swung up to levels considerably higher than the previous horizontal controls (Chart 1). Likewise upon reocclusion of the circulation in the limbs, after 15 seconds of reactive hyperemia and an associated fall in arterial pressure, there was an overshoot to levels higher than existed before the release of the cuffs (Chart 2). Finally, following the Valsalva maneuver there was a marked overshoot of arterial pressure above the control level (Chart 3), sometimes to more than 300 millimeters of mercury (Chart 6).

The characteristic overshoots of arterial pressure that occurred after stopping such stimuli in normally innervated subjects usually appeared within 5 seconds and reached a peak within 15 seconds. They then moderated and frequently disappeared within 30 seconds after the end of the stimulus, although they occasionally persisted for a minute or more. No response was accepted as neurogenic in origin that was not present within 15 seconds of stopping the stimulus.

Grading vasopressor reactivity. Because of the ease and objectivity of using these overshoots of arterial pressure to measure vasopressor reactions to blood-pressure-lowering stimuli they were graded as negative, or grade I, II, III, or IV on the basis of their relative height. Thus, after the Valsalva stimulus, rises in mean[1] arterial pressure less than 5 per cent above the previous control levels were accepted as negative. Overshoots of 5 to 14 per cent, 15 to 24 per cent, 25 to 34 per cent, and 35 per cent or over were designated as grades I, II, III, and IV, respectively. Of all

[1]Arithmetic mean calculated simply as one-half the sum of the systolic and diastolic pressures.

TABLE II.—VASOPRESSOR RESPONSES GRADED BEFORE AND AFTER, OR ONLY AFTER OTHER TYPES OF SYMPATHECTOMY*

Subject	Before operation		Operation	After operation		
	Arterial pressure	Grade		Interval	Arterial pressure	Grade
Dic	160/80	IV	Unilateral (right) upper thoracic† D_2–D_5	1 week	145/80	II
Bud	120/70	II	Unilateral (left) subtotal thoracic C inf. –D_9	2 weeks	140/70	I
Rea	235/130	I	Unilateral (right) total thoracic D_1–D_{11}	2 weeks	220/115	I
Sac	290/140	II	Unilateral (right) total thoracic D_2–D_{12}	2 weeks	250/100	II
DeH	160/100	IV	Unilateral (right) lumbodorsal D_8–L_1	2 weeks	140/85	III
Rib	150/75	IV	Upper thoracic† D_2–D_5	1 week	135/65	II
Dic	160/80	IV	Upper thoracic† D_2–D_5	1 week	140/70	I
Bud	120/70	II	1. Subtotal thoracic (left) C inf. –D_9 & greater splanchnic nerve 2. Spinal neurectomy (left) T_3–T_6‡ 3. Upper thoracic (right) D_1–D_5†	5 weeks	125/75	I
Wil	185/110	III	Total Thoracic L = D_1–D_{12} R = D_1–D_{12}	2 weeks	140/80	Neg.
Rea	235/130	I	Total Thoracic R = D_1–D_{11} L = D_1–D_{10}	2 weeks	210/110	Neg.
Sac	290/140	II	Total Thoracic R = D_2–D_{12} L = D_2–D_{12}	2 weeks	240/110	Neg.
Oue	200/115	I	Total Thoracic R = D_2–D_{11} L = D_2–D_{12}	2 weeks	135/75	Neg.
Phi	185/115¶		Total thoracic (left) C inf. –D_{11} Lumbodorsal (right) D_8–L_2	1¼ years	225/130	II
Dun	150/90	IV	Supradiaphragmatic R = D_7–D_{12} L = D_8–D_{12}	2 weeks	135/75	IV
Shi	220/150¶		Supradiaphragmatic	1½ years	235/135	I
Cra	130/80 to 180/130¶		Supradiaphragmatic R = D_9–D_{12} L = D_9–D_{12}	4 years	175/115	II
Utt	230/140¶		Supradiaphragmatic	4½ years	225/130	III
Shep	240/120¶		Supradiaphragmatic	6 years	220/125	II
And	210/150¶		Infradiaphragmatic§	4½ years	240/130	III
Rub	210/120¶		Infradiaphragmatic‖ R = L_1—L_3 L = L_1–L_3	8½ years	240/110	II

*The first footnote in Table I applies except as noted. The exact extent of previous operations elsewhere has been indicated when known.
†Greater splanchnic nerve(s) left intact.
‡Intravertebral section of dorsal and ventral spinal nerve roots proximal to dorsal root ganglia and excision of segments 2 cm. or more laterad, including roots, ganglia, and mixed nerves. Intervals between the operations listed were 8 weeks between first and second, and 16 weeks between second and third.
§The three splanchnic nerves presumably were divided bilaterally below the diaphragm. No information was available as to the ganglia removed.
‖The three splanchnic nerves were divided bilaterally below the diaphragm, and a portion of the celiac ganglion was excised. Bilateral nephropexy also was performed with the sympathectomy in two stages.
¶As reported, taken with sphygmomanometer.

the stimuli tried the Valsalva maneuver was the most useful because it was easy and quick to do and could be repeated as often as desired. Therefore it came to be the standard test in grading vasopressor reactivity. Nevertheless the other two stimuli were also applied whenever possible and responses to them were used if necessary in grading reactivity.

Effects of various types of sympathectomy. After surgical removal of various portions of the sympathetic nervous system in these subjects pressor responses to the same stimuli were frequently changed. This was evident most strikingly when there was a complete abolition or a great reduction in the overshoots that previously had occurred after stopping

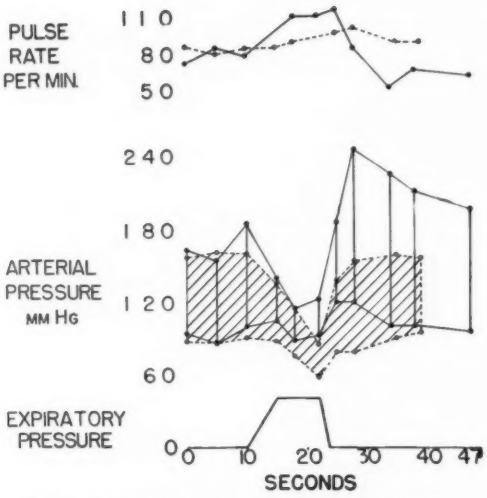

Chart 3. Showing the effects of the Valsalva maneuver (10 seconds of forced expiration) in a hypertensive patient before and after a lumbodorsal sympathectomy. Other notations as in Chart 1.

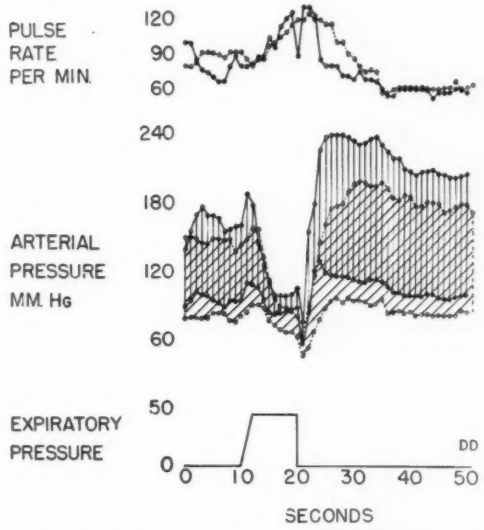

Chart 4. Showing the effects of the Valsalva maneuver in a hypertensive patient before and after a supradiaphragmatic splanchnicectomy. Other notations as in Chart 3.

such stimuli. Instead of the quick swing above the control level there was now a slow recovery, often requiring 15 to 45 seconds to return to the control level (Charts 1, 2, 3, 5, 6). Thus, patients previously rated as strong reactors to the stimuli became negative or low grade reactors.

Table I summarizes the results in a group of patients studied before and after or only after lumbodorsal splanchnicectomy (2). Prior to operation the responses of all except 2 of 20 patients were grade II or higher, whereas shortly (about 2 weeks) after operation with two exceptions they were all negative. Of 12 patients studied late (5 months to 9 years) after lumbodorsal sympathectomy 2 had grade II, 6 had grade I, and 4 had negative responses. Four patients who before total thoracic sympathectomy were grade III, I, II, and I reactors, respectively, became negative after operation (Table II) (Chart 2).

On the other hand, patients with less extensive operations remained reactive to the blood-pressure-lowering stimuli (Table II). After unilateral sympathectomy, whether lumbodorsal, total thoracic, or cardiac in type, definite though sometimes reduced vasopressor responses were observed. Bilateral cardiac ("upper thoracic") sympathectomy considerably modified but did not abolish the vasopressor overshoot. Thus, 2 young patients complaining of nervousness, tachycardia, and palpitation were both grade IV reactors before cardiac sympathectomy, whereas afterward they were relieved of their complaints and were only grade I and II reactors, respectively. Another patient (grade II) who for the relief of angina pectoris had a subtotal thoracic sympathectomy and greater splanchnic neurectomy on the left side and an upper thoracic sympathectomy on the right side was a grade I reactor 5 weeks after the last operation. (The second of his 3 operations listed in Table II was done in an effort to relieve persistent thoracic pain.) A fourth patient, who had had a left total thoracic sympathectomy and a right lumbodorsal splanchnicectomy because of angina pectoris associated with hypertension, presented the interesting finding of grade II reactivity 1¼ years postoperatively (Table II).

In one young male ("Dun") who wished to avoid any possibility of sterility a supradiaphragmatic splanchnicectomy was performed,

TABLE III.—VASOPRESSOR RESPONSES GRADED BEFORE AND AFTER, OR ONLY AFTER EXTENSION OF SYMPATHECTOMY*

Subject	Previous operation	Interval	Arterial pressure	Grade	Extending operation	Interval	Arterial pressure	Grade
Shep	Supradiaphragmatic	3½ years	220/125	II	Transthoracic R=D1–D10 L=D1–D10	2 weeks	230/120	Neg.
Cra	Supradiaphragmatic R=D9–D12 L=D9–D12	4 years	175/115	II	Transthoracic L=D2–D7 R=D1–D8	2 weeks	135/90	Neg.
Utt	Supradiaphragmatic†	4½ years	225/130	III	Unilateral (right) lumbodorsal D12–L2	1 week	250/150	I
Utt	Supradiaphragmatic†	4½ years	225/130	III	Lumbodorsal R=D12–L2 L=D11–L2	2 weeks	150/100	Neg.
And	Infradiaphragmatic	4½ years	240/130	III	Lumbodorsal R=D8–L1 L=D8–L1	2 weeks	200/130	Neg.
Rub	Infradiaphragmatic R=L1–L3 L=L1–L3	8½ years	240/110	II	Supradiaphragmatic R=D8–D12 L=D8–D12	2 weeks	185/90	Neg.
Tho	Lumbodorsal R=D8–L1 L=D8–L2	2 years	140/100‖		Transthoracic‡ L=D1–D7 R=D1–D7	3 weeks	150/90	Neg.
Kom	Lumbodorsal R=D8–L2 L=D8–L2	2 years	175/110‖		Transthoracic‡ L=D1–D7 R=D1–D7	7 months	240/105	Neg.
Abe	Lumbodorsal R=D8–L3 L=D8–L3	2⅔ years	225/125	P	Transthoracic§ R=D1–D6 L=C inf.–D5	2 weeks	205/105	Neg.
Ret	Lumbodorsal R=D8–L2 L=D8–L1	3 years	220/130	Neg	Transthoracic‡ R=D1–D5 L=D1–D7	2 weeks	210/110	Neg.
Gre	Lumbodorsal R=D8–L2 L=D8–L2	3 years	195/125‖		Transthoracic‡ L=D1–D6 R=C inf.–D7	1 year	265/120	Neg.

*Remaining portions of the greater splanchnic nerves were removed entirely whenever possible. The exact extent of previous operations elsewhere has been indicated when known. Numbers designating sympathetic ganglia and segments of trunks excised are inclusive. The first five patients are listed also in Table II, and patients "Abe" and "Ret" also in Table I.

†"Six inches of the splanchnic nerve was removed above the diaphragm on both sides as well as corresponding portions of the sympathetic trunks."

‡Final result: subtotal sympathectomy with only thoracolumbar chain ganglia below L1 or L2 remaining.

§Extravertebral spinal neurectomy of a 4 cm. segment of the third intercostal nerve was also performed bilaterally. The final surgical result was almost a total sympathectomy.

‖As reported, taken with sphygmomanometer.

leaving the lumbar ganglia intact. He was a grade IV reactor before surgery with a 50 per cent overshoot of the mean arterial pressure after the Valsalva test, and following operation he was still grade IV with a 40 per cent overshoot (Table II) (Chart 4). Of 4 other patients studied 1½, 4, 4½, and 6 years, respectively, after similar operations one was a grade III, two were grade II, and one was a grade I reactor. The grade III reactor was reduced to grade I after unilateral, and to negative after bilateral, lumbodorsal extension downward (Table III). The two grade II reactors both became negative after transthoracic extension upward (Table III) (Chart 5).

Two patients who 8½ and 4½ years previously had had infradiaphragmatic operations were grades II and III, respectively, but after a supradiaphragmatic extension in the first and a lumbodorsal extension in the second both were negative (Tables II and III) (Chart 6). Three patients who already had had "subtotal sympathectomy" (lumbodorsal previously, followed by transthoracic extension) before they were studied were all negative reactors (Table III). Two others were grade I and negative respectively about 3 years after a previous lumbodorsal splanchnicectomy, and both were negative 2 weeks after transthoracic extension of the sympathectomy upward.

DISCUSSION

The methods described above seem to furnish a means of assessing the relative amount of sympathetic nervous vasopressor reactivity especially in any one individual tested under different conditions, as before and after sympathectomy. The Valsalva test in particular appears to be valuable clinically, since the degree of overshoot following this one simple maneuver seems to be well correlated with the amount of splanchnic sympathetic innervation remaining intact, provided the cardiac acceleratory nerves have not been interrupted.

It appears that such vasopressor responses to blood-pressure-lowering stimuli depend up-

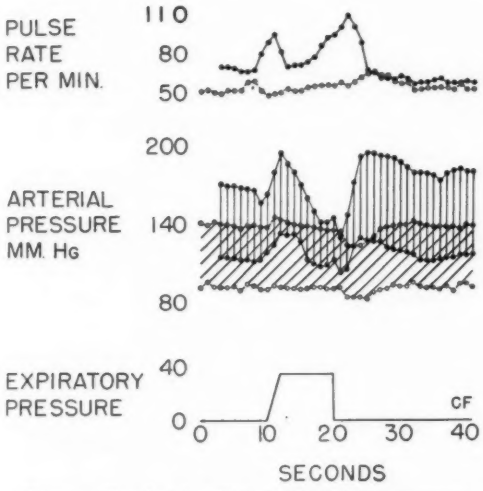

Chart 5. Showing the effects of the Valsalva maneuver before and after an extension of a supradiaphragmatic splanchnicectomy to a total thoracic sympathectomy. Other notations as in Chart 3.

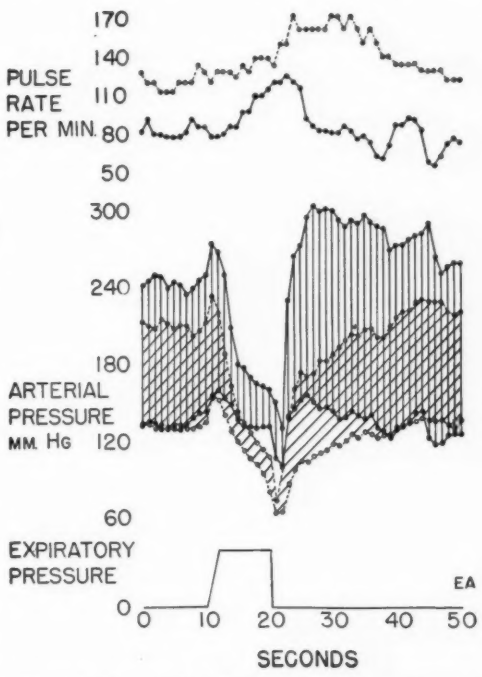

Chart 6. Showing the effects of the Valsalva maneuver before and after an extension of an infradiaphragmatic splanchnicectomy to a lumbodorsal splanchnicectomy. Other notations as in Chart 3.

on the *quantity* as well as the *location* of the functioning sympathetic nervous tissue. Thus, a total thoracic sympathectomy in which the lumbar ganglia are left intact is more effective in abolishing the responses than is a supradiaphragmatic splanchnicectomy or an upper thoracic sympathectomy leaving the same ganglia intact. On the other hand, an infradiaphragmatic operation removing the first and second lumbar ganglia but extending upward only to include the 12th dorsal ganglia is less effective in reducing the overshoots than is a lumbodorsal sympathectomy from the 8th dorsal through the first lumbar ganglia. However, a total thoracic sympathectomy or even a "subtotal sympathectomy" (lumbodorsal plus upper thoracic denervation) is no more effective than a complete lumbodorsal operation. In fact, it is possible that total thoracic sympathectomy may appear to be more effective in abolishing purely vasoconstrictor activity than it actually is, since by preventing the cardiac acceleratory component of the vasopressor response it retards and lessens the overshoot, masking any vasoconstriction that may be present. A simple cardiac denervation (i.e., a high thoracic sympathectomy) likewise minimizes the acceleratory response but also decreases both the diastolic and systolic overshoot, suggesting that certain fibers concerned in the vasoconstrictor reaction may be interrupted by the operation.

From the study of cases long after operation it appears that the type and extent of the original surgical procedure are more important factors than is the elapsed time in affecting the vasopressor response found later. This indicates that after extensive operations regeneration is usually slight, a most important fact to know whenever a poor result or a recurrence of symptoms is found after operation.

Finally, the results show that sympathetic vasopressor responses to blood-pressure-lowering procedures may be superimposed upon any grade of basal arterial pressure, the height of which may bear no direct relationship to the degree of this type of activity and may or may not be changed by procedures which profound-

ly alter the reflex responses. If superimposed upon a high basal level of arterial pressure such reactions may result in dangerously high peaks during which vascular rupture or other types of damage may occur. In such cases it would seem wise to abolish the reflex vasopressor responses even when the basal levels of arterial pressure might not be lowered by the operation. This conclusion apparently has been justified by the more benign course of many hypertensive patients after a sympathectomy which has failed to produce a significant change in the basal arterial pressure.

SUMMARY AND CONCLUSIONS

1. Overshoots of arterial pressure appearing quickly after the cessation of blood-pressure-lowering procedures furnish a means of grading the amount of sympathetic nervous vasopressor reactivity of human subjects.

2. The grade of vasopressor reactivity of a subject is markedly decreased or abolished after extensive bilateral sympathectomy. It is less affected by less extensive sympathetic denervations.

3. The grade of vasopressor reactivity is not necessarily related to the resting level of arterial pressure of a subject.

4. The abolition of overshoots of arterial pressure in hypertensive patients appears highly desirable.

REFERENCES

1. Hamilton, W. F., Brewer, G., and Brotman, I. Am. J. Physiol., 1934, 107: 427.
2. Smithwick, R. H. Surgery, 1940, 7: 1.
3. Starr, I., Rawson, A. J., Schroeder, H. A., and Joseph, N. R. Am. J. Physiol., 1933, 127: 1.
4. Wilkins, R. W., and Eichna, L. W. Bull. Johns Hopkins Hosp., 1941, 68: 425.
5. Wilkins, R. W., Friedland, C. K., and Bradley, S. E. Estimations of Cardiac and Vasomotor Reserve, Especially in Response to Strains Designed to Simulate Those of Acceleration. National Research Council, C.A.M. Report No. 177, 1943.
6. Wilkins, R. W., and Culbertson, J. W. Tr. Ass. Am. Physicians, 1947, 60: 195.
7. Wilkins, R. W. Am. Heart J. 1943, 26: 351.

FECAL CONTINENCE FOLLOWING RESECTIONS OF VARIOUS PORTIONS OF THE RECTUM WITH PRESERVATION OF THE ANAL SPHINCTERS

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IN a previous communication studies on the physiology of fecal continence in normal individuals were presented (2). The purpose of this paper is to present similar studies of 4 patients in whom the anal sphincters have been retained following resections of various portions of the sigmoid colon and rectum. Interpretation of these studies is aided by kymographic tracings of the anal reflexes obtained on stimulation of different levels of the sigmoid and rectum in normal individuals. These studies indicate that the rectum itself is an integral part of the sphincteric apparatus and that the retained sphincters are incapable of maintaining sphincteric continence if too much of the rectum is removed.

SPHINCTERIC CONTINENCE IN NORMAL INDIVIDUALS

It is of the greatest importance to understand that fecal continence may be of two types, colonic and sphincteric. Colonic continence refers to the plastic adaptation of the smooth muscle of the colon to the enlarging fecal mass; it is retained following resections of the rectum whether the sphincters are preserved or not. Thus, even in patients with abdominal colostomy in whom there is no sphincteric apparatus, attention to diet and colonic irrigations at regular intervals eventuates in a type of continence which is surprisingly satisfactory. Failure to evaluate the role played by colonic continence, when the anal sphincters have been preserved following resections of the rectum, may lead to erroneous conclusions as to the efficiency of the retained sphincters.

Sphincteric continence refers to the conscious and especially to the reflex retention of bowel contents by contraction of the external sphincter muscle. The internal sphincter, which relaxes when the rectum is stimulated, appears to play no part in sphincteric continence. Since sphincteric contraction is not associated with any damping effect on colonic peristalsis (1), the closing force of the sphincter must exceed the propulsive force of the colon in order to be effective. The normal external anal sphincter has been shown to lack endurance. This lack of endurance makes necessary a mechanism whereby the sphincter may be warned as to when and to what degree its services are required. Previously reported studies of normal individuals indicate that such a mechanism exists in the form of a reflex arc. The afferent fibers of this arc arise in the wall of the rectum and communicate at cerebral levels with efferent fibers which terminate in the external anal sphincter (2).

Under normal circumstances colonic and sphincteric continence are of equal importance. Colonic continence appears to be responsible for the retention of feces over long periods of time through the plastic adaptation of the smooth muscle of the colon. When this plastic adaptation reaches an end and peristalsis begins, the fecal masses are pushed into the rectum in the wall of which afferent impulses are initiated. These afferent impulses, traveling over nervous pathways, (a) give rise to a sensation of imminent defecation located in the perineum, and (b), initiate a reflex by which the external sphincter is able to contract sufficiently to resist the propulsive force of colonic peristalsis. Sphincteric resistance to colonic peristalsis is followed by further plastic adaptation of the colon and rectum and appropriate relaxation of the sphincter. Sphincteric continence is, therefore, an emergency mechanism which is called into play for only relatively short periods of time.

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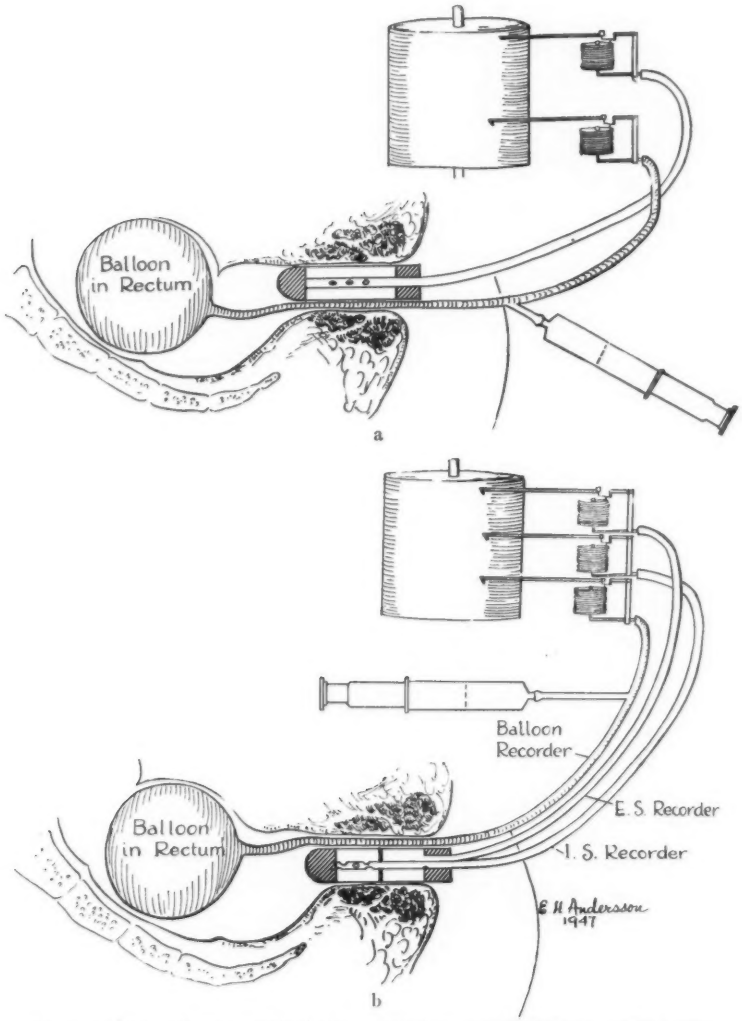

Fig. 1. a, Single obturator method of recording changes in sphincter tone that accompany stimulation of the rectum. b, Double obturator method which permits simultaneous and independent recording of the changes of tone of the internal and external sphincters.

METHODS AND MATERIAL

The anal reflexes were studied by means of the apparatus illustrated in Figures 1a and b. The rectum or colon was stimulated with a rubber balloon which was filled by increments and emptied by decrements with a syringe. Pressure changes in the balloon were recorded kymographically. Changes in anal sphincter tone resulting from this stimulation were also recorded kymographically by means of a single (Fig. 1a) or double (Fig. 1b) obturator. The combined activities of the internal and external sphincters were recorded by placing the single obturator across the entire anal

canal. When the single obturator was pushed into the anal canal so that only its proximal half was recording, while its distal half protruded into the cavity of the rectum, changes of tone of the internal sphincter were recorded. When the single obturator was pulled partially out of the anal canal so that only its distal half was compressed it was possible to record the activity of the external sphincter. The double obturator was divided by a thin metal septum into proximal and distal compartments each of which was connected for independent kymographic recording. When the septum was placed at about the middle of the anal canal the activities of the internal and external anal sphincters were recorded simultaneously and independently.

By these methods studies were made of the anal reflexes of 12 normal individuals in whom the stimulating balloon was placed at various levels in the sigmoid and rectum. Studies were also made on 4 patients in whom the following surgical procedures had been previously carried out: (1) resection of the distal sigmoid colon and all of the rectum with anastomosis at the mucocutaneous line; (2) anterior resection of the sigmoid with anastomosis at the level of the peritoneal reflection; (3) resection of the sigmoid and upper half of the rectum with anastomosis 7 centimeters above the anus; (4) resection of the sigmoid and rectum with anastomosis 1 centimeter to 2 centimeters above the anus.

The number of surgical cases is small because the indications for sphincter preservation in the presence of malignancy have been rigidly limited to the following situations: (1) very early tumors involving one-half or less of the circumference of the bowel and with the lower border of the tumor at least 6 centimeters and preferably 8 centimeters or more above the proposed site of anastomosis; (2) palliative resections done in the presence of liver metastases when the tumor lies at least 5 centimeters above the site of anastomosis.

RESULTS

A. The anal reflexes resulting from stimulation of different levels of the rectum and sigmoid in normal adults. In 12 normal adults the changes in tone of the internal and external anal sphincters were recorded during stimulation of the sigmoid colon and rectum at various levels by means of the balloon. All such experiments gave essentially similar findings and a typical example is illustrated in Figure 2. A, B and C of Figure 2 are the results of three separate tests made in the same individual with the balloon at different levels. These and subsequent illustrations are similarly arranged so that the upper line represents the activity of the external sphincter, the middle line the internal sphincter, and the lower line the filling (upward curves) and emptying (downward curves) of the balloon by increments and decrements. In all tests illustrated in Figure 2 the increments and decrements were each 50 cubic centimeters. Simultaneous ordinates on the three graph lines of each test are indicated by small letters.

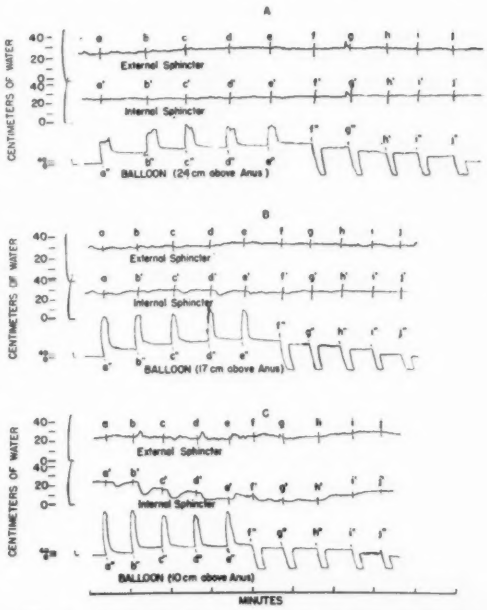

Fig. 2. Kymographic tracings of the changes of external and internal sphincter tone in a normal adult with the stimulating balloon placed at various levels above the anus. In A, the balloon was 24 centimeters above the anus, in B, 17 centimeters above the anus and in C, 10 centimeters above the anus. Small letters of each test indicate simultaneous ordinates. Pressure scales in centimeters of water.

During test A the stimulating balloon was placed in the sigmoid colon 24 centimeters

above the anus. Filling the balloon with 5 increments caused no change in the tonus of either the internal or external anal sphincter. The same is true of the 5 decrements by which the balloon was emptied. In test B the balloon was placed in the upper rectum, 17 centimeters above the anus. With each increment of filling of the balloon the internal sphincter tone fell for a short time after which it returned to the preinjection level. There was no change in external sphincter tone during these injections. No significant changes of either internal or external sphincter tone were recorded with the decrements of emptying. In test C the balloon was placed 10 centimeters above the anus. Each increment of filling was accompanied by a partially sustained fall of internal sphincter tone of significant degree. During the decrements of emptying of the balloon there was a considerable recovery of internal sphincter tone. At the same time that the internal sphincter tone was falling, the external sphincter tone not only did not fall but, at points *a*, *b*, *d*, and *e* showed significant elevations of a short period of time.

Figure 2 demonstrates that both the internal and external sphincter responses become more active when the stimulating balloon is placed closer to the anus. When the stimulus is applied to the sigmoid colon, no reflex activity of either sphincter is recorded. When the stimulus is applied to the upper rectum the sphincter responses are present but feeble. They become progressively greater as the stimulus is applied closer to the anus. These findings indicate that the receptor units of the anal reflexes are absent in the sigmoid colon, that they are relatively sparse in the upper rectum but that they become progressively more numerous per unit area as the anus is approached. This receptor mechanism, present only in the rectum, is therefore the origin of afferent stimuli by means of which warning is given to the external sphincter as to when and to what degree contraction is required to maintain sphincteric continence. The consistent fall of internal sphincter tone when the rectum is stimulated illustrates again that this part of the sphincteric mechanism prepares the way for evacuation of feces and that it plays no part in sphincteric continence.

The sensations resulting from distending a balloon in various parts of the colon and rectum have been described by Hertz, and were amply confirmed in this group of normal individuals. When the balloon was placed in the sigmoid its distention caused discomfort in the lower abdomen, usually in the midline but often in the left lower quadrant. Distention of the balloon when it was in the upper rectum caused a sensation in the sacral or perineal region that was interpreted as an urge to defecate. The lower in the rectum the balloon was placed the greater was the sacral or perineal sensation that resulted from an equal degree of distention. An evaluation of the sensation experienced by the patient when defecation was imminent was thus of some value in establishing the presence of functioning afferent nerve fibers arising in that portion of the rectum that had been retained.

B. Loss of sphincteric continence following resection of all of the rectum. A 53 year old woman (Framingham Union Hospital No. 72755) had an early, grade 2 adenocarcinoma involving one third of the circumference of the rectum. The lower border of the tumor was 8 centimeters above the anus. Eighteen months before this study the distal half of the sigmoid and all of the rectum were resected and an anastomosis of the sigmoid colon to the anal canal at the level of the mucocutaneous line was accomplished, a modification of the "pull through" technique being used. A transverse colostomy was also done. After healing was complete and the line of anastomosis had been dilated to normal size, the transverse colostomy was closed.

Since recovery from the operation the patient remains able voluntarily to contract the anal sphincter with good force, and healing has been so perfect that, on examination, there is little to suggest that the rectum has been removed. In spite of this apparently perfect anatomical result she remains unable to retain gas and feces.

This intelligent and co-operative patient has made pertinent observations on the mechanism of the incontinence. She states that the perineal sensation which before operation indicated a desire to defecate, is no longer present. When gas or feces passes through the anal canal,

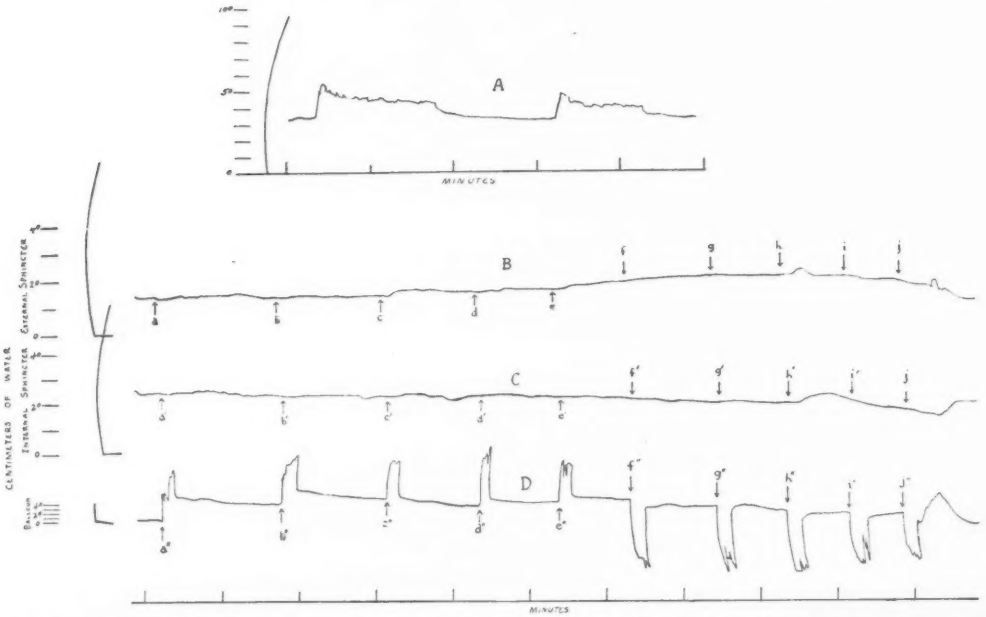

Fig. 3. Tracings taken from patient in whom the entire rectum was resected with anastomosis of sigmoid to anus at the mucocutaneous line. A, Single obturator across entire anal canal records two voluntary sphincter contractions. B, External sphincter tone and C, internal sphincter tone recorded simultaneously with the double obturator. D, filling, a″ to e″, and emptying, f″ to j″, of balloon placed 10 centimeters above the anus.

however, a normal sensation of evacuation is present. When the anal sensation is noted the sphincter is voluntarily contracted but not until after some gas or feces has escaped. In other words she has no knowledge of when or to what degree to contract the external sphincter until bowel content has passed beyond the point where it can be controlled by sphincteric contraction.

This analysis by the patient was confirmed by carefully observing sphincteric activity during an enema. The colon was sufficiently filled to set up peristaltic waves, which were recorded kymographically, and it was shown that each elevation of pressure in the "rectum" preceded by an appreciable period the onset of sphincteric contraction. It was repeatedly noted that sphincteric contraction did not take place until after enema fluid had escaped through the anal canal.

The effect of resection of the rectum on the anal reflexes in this patient is illustrated in Figure 3. The graph line marked "A" was made with the single obturator across the entire anal canal and records two voluntary sphincter contractions both of which fall well within the range of normal in both strength and duration (2). These indicate a good anatomical result. Lines "B" and "C" indicate, respectively, the activities of the external and internal sphincters as recorded with the double obturator during stimulation of the bowel by means of a balloon placed 10 centimeters above the anus. Line "D" shows 25 cubic centimeter increments of filling (upright curves *a″* to *e″*) and decrements of emptying (downward curves f″ to j″) of the balloon. As would be expected from the results of tests on normal individuals, no reflex activity of the sphincters resulted from stimulation of that portion of the sigmoid colon which had been placed in the pelvis to replace the resected rectum and the similarity to test A in Figure 2 is evident.

During recent months this patient has been on a colostomy regimen, consisting of a constipating diet and colonic irrigations every sec-

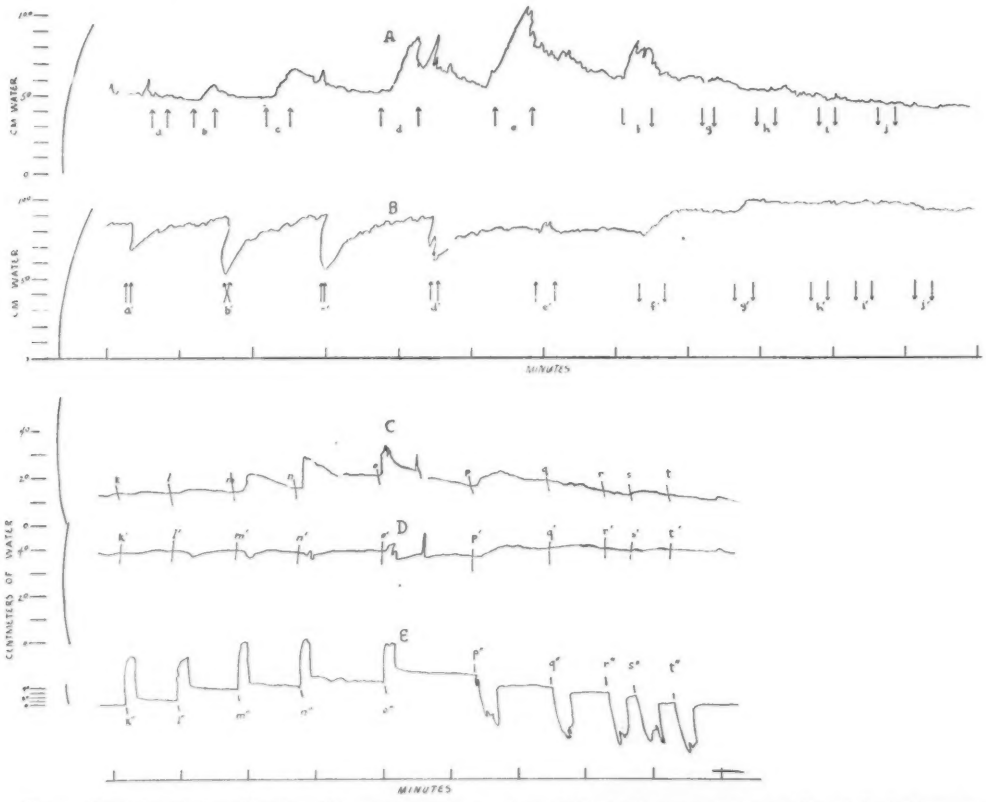

Fig. 4. Resection of sigmoid colon with anastomosis at level of peritoneal reflection. A, External sphincter and B, internal sphincter recorded with the single obturator. Arrows pointing up indicate increments of filling of the balloon placed 10 centimeters above the anus. Arrows pointing down indicate decrements of emptying of the balloon. C, External sphincter and D, internal sphincter tone recorded simultaneously with the double obturator. E, Filling and emptying of the balloon placed 10 centimeters above the anus.

ond day. By this means regular bowel habits have developed to such a degree that she is rarely embarrassed. This is the same type of continence that is developed by patients with abdominal colostomy. It is colonic continence and has nothing to do with the retained anal sphincters. The retained sphincters are of no practical value and, from the standpoint of fecal continence, the patient has no more than a perineal colostomy. It is of some interest that she much prefers the present perineal opening to the abdominal colostomy which for several months she managed with equal skill. The chief reason for this preference is the greater ease and cleanliness with which colonic irrigations can be evacuated through the perineal opening. The cosmetic disadvantages of the abdominal colostomy are an important secondary reason.

C. Preservation of sphincteric continence following anterior resection of the sigmoid with anastomosis at the level of the peritoneal reflection. Because the anal reflexes are elicited in normal adults only on stimulation of the rectum and not on stimulation of the sigmoid colon, it might be anticipated that sphincteric continence would not be altered by anterior resection of the sigmoid with anastomosis at the level of the peritoneal reflection. That such is the case is illustrated in Figure 4. These

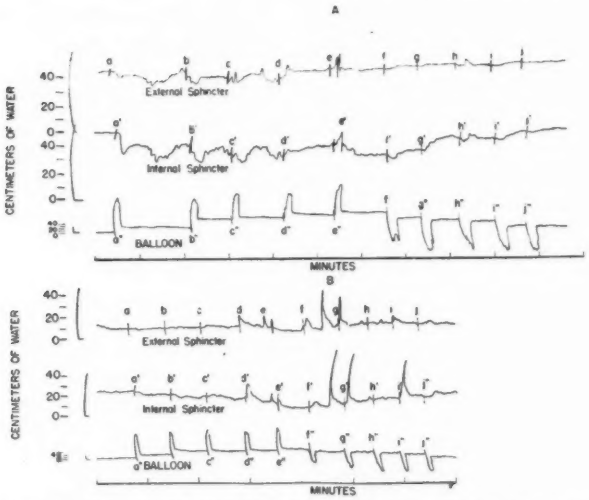

Fig. 5. Resection of sigmoid and upper rectum with anastomosis 7 centimeters above the anus. A, Before operation. External and internal sphincter tone recorded simultaneously with double obturator. Balloon 10 centimeters above anus. B, After operation, double obturator method. Balloon 5 centimeters above anus.

graphs were obtained from a 61 year old woman (Framingham Union Hospital No. 75445) following resection of a grade 3 adenocarcinoma of the middle of a long loop of sigmoid colon. The sigmoid and its mesentery were resected and an anastomosis was completed between the descending colon and the "rectosigmoid junction." Following recovery the patient noted no change in her ability to retain gas or feces by sphincteric contraction and imminent defecation was associated with a normal perineal sensation.

In Figure 4 lines "A" and "B," representing respectively the activities of the external and internal sphincters, were obtained with the single obturator. The balloon was placed 10 centimeters above the anus. Arrows pointing upward indicate the beginning and end of injections of 50 cubic centimeter increments into the balloon (*a* to *e* and *a'* to *e'*) while arrows pointing down (*f* to *j* and *f'* to *j'*) indicate the withdrawal of 50 cubic centimeters decrements. The normal contraction response of the external sphincter and the normal relaxation response of the internal sphincter are well shown. Lines "C" (external sphincter) and "D" (internal sphincter) were obtained simultaneously with the double obturator. Line "E" shows the filling (upward curves) and emptying (downward curves) of the balloon placed 10 centimeters above the anus. Normal reflex responses of both sphincters are again evident. These findings indicate that the rectoanal reflexes have not been altered by resection of the sigmoid colon.

D. Preservation of sphincteric continence following resection of the sigmoid and upper rectum with anastomosis 7 centimeters above the anus. Since it has been shown that resection of all of the rectum causes loss of sphincteric continence while resection of the sigmoid with preservation of the rectum does not alter sphincteric continence, the question arises as to how much rectum must be retained, along with the sphincters, to conserve sphincteric continence. That sphincteric continence is retained when the distal half of the rectum is preserved is illustrated by the following case.

A 64 year old man (Framingham Union Hospital No. 77927) was found to have an annular, grade 3 adenocarcinoma of the sigmoid 20 centimeters above the anus. There was in addition a malignant, rectal polyp 0.5 centimeter in diameter located 10 centimeters above the

anus. At operation the tumor of the sigmoid was found to have invaded the serosa and 6 or 8 metastatic masses, each about 2 centimeters in diameter, were palpated in the liver. A palliative resection of the sigmoid and of the proximal half of the rectum was done. A rectosigmoidal anastomosis 7 centimeters above the anus was established by a modification of the "pull through" technique.

Since recovery from the operation the patient has noted absolutely no change in his ability to retain bowel contents by sphincteric contraction. Imminent defecation is associated with a normal perineal sensation which is in no way altered from the preoperative state. Bowel habits have not been changed and it has not been necessary to resort to cathartics, enemas or change of dietary habits.

Preoperative and postoperative studies of the rectoanal reflexes are illustrated in Figure 5. Both studies were done with the double obturator. In graphs "A," obtained before operation, the balloon was placed 10 centimeters above the anus and was filled and emptied by increments and decrements of 50 cubic centimeters each. Due to a considerable degree of overlapping of the internal sphincter by the external, the two graphs of sphincter activity show a superficial similarity. It is possible, however, to distinguish the sustained fall of internal sphincter tone resulting from filling of the balloon and the recovery of tone as the balloon is emptied. There is no sustained fall of the tone of the external sphincter and purposeful contractions of the external sphincter may be readily distinguished.

In graphs "B," obtained after operation, it was necessary to use a smaller, doughnut shaped balloon placed 5 centimeters above the anus. Because of the smaller area of rectum available for stimulation the balloon was filled and emptied by increments and decrements of 25 cubic centimeters each. Again the overlapping of one sphincter by the other makes the two graph lines superficially similar, yet it is possible to distinguish the sustained fall of internal sphincter tone and the sharp, momentary contractions of the external sphincter as the balloon is filled.

Both the clinical and experimental findings in this case indicate that sphincteric continence is not compromised following rectosigmoidal resection when the distal 7 centimeters of rectum is retained.

E. Equivocal result following resection of the sigmoid and rectum with anastomosis 1 to 2 centimeters above the mucocutaneous line. A 60 year old man (Framingham Union Hospital No. 78221) was found to have an early, grade 2 adenocarcinoma of the rectum; the lower border was 9 centimeters above the anus. The tumor was 3 centimeters in diameter, involved only about one-third of the circumference of the rectum and was freely movable on the underlying tissues. At operation the distal half of the sigmoid and all of the rectum except the distal 1 to 2 centimeters were resected. Anastomosis of the proximal sigmoid and the retained rectum was established by a modification of the "pull through" technique. A transverse colostomy, done at the time of the resection, was closed after the anastomosis had been properly dilated and was well healed. After healing was complete the line of anastomosis was found to be oblique, with 2 centimeters of rectum retained above the mucocutaneous line at the anterior commissure and only 1 centimeter above the mucocutaneous line at the posterior commissure.

For 20 years preceding operation, the patient required a cathartic two or three times a week, rarely having a bowel movement without such medication. Since recovery he has taken no cathartics and, two or three times weekly has had normal, soft, formed stools. The urge to defecate has been associated with an abdominal, cramp-like sensation which has given ample warning. Imminent defecation is now associated with a perineal sensation which is quantitatively less than the sensation he had before operation. There is also a qualitative difference in the sensation which he is unable to describe. The external sphincter can be voluntarily contracted with good force and the patient is not conscious of any loss of strength in this muscle. He believes himself to be continent although he makes no effort to control gas.

Preoperative studies of the rectoanal reflexes showed both the internal and external sphincters to respond normally when the rectum was stimulated with a balloon. Postop-

erative studies indicated that the voluntary sphincter contraction compared favorably in both strength and duration with those of many normal individuals. Numerous attempts to elicit the anal reflexes by stimulation of the remaining rectum, the region of the anastomosis, and the sigmoid immediately above the anastomosis were uniformly unsuccessful. These failures may be related to the mechanical difficulties of applying the stimulus to the small area of rectum that remains. The lumen of the sigmoid immediately above the anastomosis is relatively narrow as compared with that of the remaining rectum, while the anastomosis itself contains scar tissue which is quite inelastic. When even the smallest, doughnut shaped balloon is distended below the anastomosis, it tends to push out through the anus and to interfere with the obturator. When a balloon is distended above the anastomosis, it tends to migrate up the sigmoid unless forcibly held in place by traction on the attached catheter, and even then appears to cause no stretching of the wall of the contiguous rectum because of the lack of resilience of the anastomosis. It is also possible that this failure to elicit the rectoanal reflexes is related to operative trauma to the afferent nerves arising in the remaining rectum. This seems unlikely because the perineal sensation that accompanies imminent defecation has not been abolished, even though it is diminished in intensity and changed in quality. The diminished intensity of the sensation may be explained on the basis that almost complete resection of the rectum has eliminated most of the receptor units in which it arises. The change in quality of the sensation is more difficult to explain. It may be a faulty observation on the part of the patient.

In an effort to secure objective evidence of the persistence of sphincteric continence following operation, a saline enema was given. During the injection small amounts leaked out through the anus on several occasions but was promptly controlled by sphincteric contraction. This observation suggested that the sphincter contracted only after fluid had entered the anal canal and thus too late to be controlled. After 500 cubic centimeters had been injected a strong urge to defecate was established. When the patient was then allowed to get on his feet about 100 cubic centimeters leaked out through the anus, coming in irregular spurts. The remaining fluid was retained for some time after which it was evacuated, along with a large quantity of normal stool, without difficulty.

At the present time, 4 months after closure of the transverse colostomy, the functional result in this patient remains equivocal. His ability to retain solid fecal material may well be the result of colonic continence which would have been retained even had the sphincters been sacrificed. Objective evidence of true sphincteric continence has not been obtained although the presence of a perineal sensation when defecation is imminent suggests that functioning afferent fibers are present in the small amount of rectum that remains. Theoretically these fibers should carry the impulses which give warning as to when sphincteric contraction is required. The observations made during and after the enema suggest that insufficient rectum, and therefore insufficient afferent fibers, have been retained adequately to initiate the rectoanal reflexes which appear to be essential to true sphincteric continence.

SUMMARY AND CONCLUSIONS

1. The essential difference between colonic continence and sphincteric continence is again stressed. The relative importance of each type of continence is discussed.

2. The results of physiological studies of the anal reflexes in 12 normal adults are presented:

A. Stimulation of the sigmoid colon by means of an incrementally distended balloon caused no change in the tonus of either the internal or external anal sphincter.

B. Stimulation of the upper rectum caused the characteristic reflex responses of both sphincters, but the responses were feeble.

C. The closer to the anus the stimulus was applied the more pronounced were the reflex changes of sphincter tone.

3. Clinical observations and physiological studies on 4 surgical patients with anastomoses at various levels of the rectum are presented:

A. Resection of all of the rectum with anastomosis of sigmoid to anus at the level of the

mucocutaneous line resulted in loss of sphincteric continence and the rectoanal reflexes could not be elicited.

B. Resection of the sigmoid colon with anastomosis performed at the level of the peritoneal reflection caused no change in rectoanal reflexes and there was no loss of sphincteric continence.

C. Resection of the distal half of the sigmoid colon and the upper half of the rectum, with anastomosis 7 centimeters above the mucocutaneous line, caused no change in the rectoanal reflexes and no loss of sphincteric continence.

D. Resection of the sigmoid colon and rectum with anastomosis 1 to 2 centimeters above the mucocutaneous line gave an equivocal result. The rectoanal reflexes were not elicited but this may be due to the mechanical difficulties associated with applying a stimulating balloon to the small amount of rectum that remains. It is probable, however, that sphincteric continence is diminished to the point where it is of little practical value.

4. An intact reflex arc, with afferent fibers arising in the wall of the rectum and with efferent fibers terminating in the external anal sphincter, is essential for the preservation of sphincteric continence. *The rectum is therefore an integral part of the sphincteric mechanism.*

5. The minimal amount of rectum that must be retained for the preservation of sphincteric continence has not been accurately determined. It would appear that at some point between 1 and 7 centimeters above the mucocutaneous line there is a level below which the rectum can not be resected without seriously interfering with the preservation of sphincteric continence.

REFERENCES

1. Denny-Brown, D., and Robertson, E. G. Brain, Lond., 1935, 58: 256–310.
2. Gaston, E. A. Surg. Gyn. Obst., 1948, 87: 280.
3. Hertz, A. F. Lancet, Lond., 1911, 1: 1051–1056, 1119–1124, 1187–1193.

RADICAL EXCISION OF THE INGUINAL AND ILIAC LYMPH GLANDS

A Study Based upon 450 Anatomical Dissections and upon Supportive Clinical Observations

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THE location, grouping, size, and number of the inguinal and iliac groups of lymph glands are anatomical features of practical interest to all surgeons treating malignant lesions of the lower extremity, pelvis, and perineum, since metastatic involvement of these glands is a common occurrence. Relatively little has been written regarding variation in the location and extent of these glands and of structures associated with them. As a consequence, the surgical procedures which are advocated for their radical excision are likely to be generalized and inexact.

In an effort to establish a more dependable morphological basis for a procedure of choice, the authors studied the number, size, distribution, and fascial relations of the glands, and then sought to devise a technique which would be both surgically feasible and anatomically sound. It is their hope that the presentation of results will be of service in the treatment of malignancies affecting primarily the inguinal and the associated iliac glands.

Material and Methods

The anatomical observations were made on dissection of 450 anatomical specimens (American whites and negroes, preponderantly male). The records on the superficial inguinal lymph glands were taken concurrently with those on the saphenous venous tributaries which were reported in an earlier issue of this journal (Daseler, Anson, Reimann, and Beaton, 1946).

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A life-sized sketch of the subcutaneous veins of the inguinofemoral region and the associated glands was prepared in each of the 450 thighs dissected. These have been employed to furnish data on distribution (Table I) and on size. Certain of the specimens, representing typical arrangements, were selected for illustration (Figs. 1, 3, 4, and 5; specimens I to VII). The locations of the ten glands most commonly encountered were recorded diagrammatically (Fig. 2).

Having established patterns and relationships by these means, and following preliminary operating-room observation, a technique for excision was further modified through the use of unfixed specimens.[1] Finally, the stages in the surgery were carried out on selected laboratory (embalmed) specimens, the steps being recorded by the artist (Figs. 6 to 8; specimen VIII). Subsequently, the method was employed by the senior author with satisfactory results. In the following account the authors will first present pertinent data on the glands, on related vessels, and on pelvofemoral layers, employing selected anatomic cases; then the technique of surgical extirpation and of repair will be discussed, as aided by the laboratory observations.

Anatomical Observations and Discussion

1. General

The inguinal lymph nodes of superficial position are regularly described as being situated in the area bounded superiorly by the inguinal (Poupart's) ligament, inferiorly by a line cross-

[1]The authors are indebted to Dr. Rollo MacCotter of the Department of Anatomy, University of Michigan, for the use of unfixed specimens in the perfection of the surgical techniques.

TABLE I.—ZONAL DISTRIBUTION OF THE SUPERFICIAL INGUINAL LYMPH GLANDS IN 450 EXTREMITIES (compare with Fig. 2)

Number	Zone 1 Upper lateral	Zone 2 Upper medial	Zone 3 Lower medial	Zone 4 Lower lateral	Zone 5 Presaph.
0	6	42	173	14	379
1	43	183	165	91	68
2	85	144	86	183	2
3	135	58	12	116	1
4	95	15	9	31	0
5	52	4	0	10	0
6	21	1	0	2	0
7	9	1	1	1	0
8	3	0	0	1	0
9	0	0	0	1	0

Average 8.25 lymph nodes per extremity.

ing the point of intersection of the sartorius and adductor longus muscles, laterally by a line dropped vertically from the anterior superior iliac spine, and medially by a similar line commencing at the pubic tubercle.[1] However, to be more exact, in the 450 extremities examined during the course of the present study, these glands were in all cases found within the confines of a quadrilateral area bounded as follows: superiorly, by a line 12 centimeters in length parallel to, and 1 centimeter above, the inguinal ligament and beginning medially just above the pubic tubercle; medially, by a line 15 centimeters long dropped perpendicularly downward from the pubic tubercle; laterally, by a similar line 20 centimeters in length, dropped from the lateral limit of the superior boundary; inferiorly by a transverse line, 11 centimeters in length, connecting the lower limits of the lateral and medial borders (see esp. Fig. 6).

The superficial inguinal glands, with the saphenous vein and its tributaries, are situated within the deeper, or typically membranous stratum, of the superficial fascia of the thigh—the superficial fascia here being two-layered (Fig. 1), just as it regularly is in the adjacent inguinal and perineal regions. The glands are covered by the superficial, or fatty, layer of the superficial fascia (Fig. 3). In slightly obese specimens, when some fat occurs in the deeper, or membranous layer, the lymph nodes and the associated veins occupy the adipose lamella of the layer. But, whether fibrous or partially fatty, the stratum is easily separable from the subjacent fascia lata (Fig. 1).

These superficial lymph glands send their efferent vessels into glands of deeper position, the latter situated along the femoral vessels within the fascial sleeve (fascia lata) of the thigh and into the iliac continuations of these vessels in the pelvis. These deep glands are lodged within the femoral sheath, in tissue which passes without interruption into the retroperitoneal (subserous) tissue of the pelvic cavity (McVay and Anson, 1940). Within the pelvis this subserous tissue forms a stratum between the peritoneum and the parietal (obturator and iliac) fascia.

Of the two major sets, the superficial offers the more difficult surgical problem, because of the relatively great expanse of their field; the deep glands, in being clustered about the iliac and femoral vessels, form simple elongate chains. The two sets will be considered separately.

2. SUPERFICIAL INGUINAL GLANDS

a. Number, size. The superficial inguinal glands vary in number from 4 to 25 (Figs. 5a to 5d). In the present series of 450 lower ex-

[1]A comment on nomenclature is appropriate here. In standard descriptions all of the glands which occupy the proximal area of the thigh, over the femoral triangle, are termed inguinal. They are divided into two groups by a horizontal line which crosses the thigh at the point of termination of the great saphenous vein in the femoral; those lying above this line are termed the *superficial inguinal nodes*, and those below it the *subinguinal nodes*. The latter group is said to consist of a superficial and a deep set.

The superficial inguinal nodes lie immediately below the inguinal ligament; the *superficial subinguinal glands* are placed on either side of the upper part of the great saphenous vein. All of these glands are situated external to the fascia lata. The *deep subinguinal nodes*, unlike the glands constituting the preceding sets, are placed under the fascia lata, close to the femoral vein. They are described as if the maximal number were three (the lowest situated just below the junction of the great saphenous and femoral veins, the middle in the femoral canal, and the highest, termed the node of Cloquet or Rosenmüller, in the femoral ring).

Actually, since but few nodes of the total series are in the inguinal region, rarely (as will be described) occurring along the line of the inguinal ligament or cranial thereto, the term *inguinal* is not suitable. And, although the name *subinguinal* would be serviceably descriptive, *femoral* would be wholly defensible. Moreover, the conventional division into *inguinal* and *subinguinal* on the basis of relation to a transverse line (at the saphenofemoral junction) is worse than arbitrary; it is entirely incorrect, since the area, between lower border of the external oblique aponeurosis and the fossa ovalis, is not inguinal.

As will become apparent through reading of the present authors' text, the zonal scheme of Rouvière is anatomically sound. It will be followed in the current discussion. The term *inguinal* will be retained, since it is, seemingly, everywhere employed. The distinction between *superficial* and *deep* groups is, of course, fundamentally serviceable.

tremities 3,715 lymph nodes were encountered, an average of 8.25 per extremity. In size the individual lymph glands range between the surface area of 10 square centimeters and 0.6 square centimeter. The size of the individual glands is usually inversely proportional to the total number of glands encountered in the individual thigh. This statement would not, of course, be applicable to cases in which the lymph glands were enlarged through malignant infiltration or suppurative involvement.

b. Zonal arrangement. According to the system of Rouvière, the superficial inguinal lymph glands are divisible into five groups in relation to areas bounded by horizontal and vertical lines, for which the point of intersection is the saphenofemoral juncture. The area is thus divided into four quadrants and a central, or fifth, zone immediately overlying the saphenofemoral juncture (Fig. 2). Von Bardeleben has stated that none of the five groups contains, regularly, more than 3 or 4 glands. However, as will be described later, in the present series, specimens were encountered in which as many as 9 lymph glands were present in a single zone (Figs. 5a to 5d).

Zone 1, or the superolateral quadrant, may contain no glands or as many as 8 lymph glands. The individual nodes are usually elongate in an oblique line paralleling that of the inguinal ligament. They are likely to be arranged in chain-like formation, situated slightly distal, or inferolateral, to the inguinal ligament and along the course of the superficial circumflex iliac vessels (Fig. 5a). The lymph glands are more numerous here, and more consistently present, than in any of the other zones. The members of this group of glands are described as receiving their afferent lymphatics from the skin of the upper gluteal region, from that of the lateral and posterior abdomen below the level of the umbilicus and occasionally from the penile skin (or the homologous praeputium clitoridis of the female).

Zone 2, or the superomedial quadrant, may be free of glands or may contain them up to the number of 7 nodes. They are usually circular in outline and clustered about the terminations of the superficial epigastric and superficial external pudendal veins (Figs. 5a and 5b). The lymph glands of this group are said to receive afferent cutaneous lymphatics from the following areas: umbilical and infraumbilical portions of the abdomen; perineum and cutaneous anal area; the scrotum; the penile skin and praeputium clitoridis; the vulva and portions of the external genitalia outside of the hymen; and rarely, from the glans penis and glans clitoridis (Rouvière). Cutaneous lymphatics from these regions, though terminating in the superomedial group of glands, have abundant anastomoses across the midline; they may therefore terminate in either the right or left side or in both. Von Bardeleben has stated that none of the glands in either the superolateral or superomedial groups (zones 1 or 2) cross, or lie cranial to, the inguinal ligament. The present authors, however, have found several specimens in which a gland was situated above the level of the inguinal ligament, but never by a distance greater than 1 centimeter.

Zone 3, or the inferomedial quadrant, exhibits the same range in number of contained glands (none to 7). They are commonly elongate, arranged with their long axes extending in a vertical direction. It is in this quadrant that glands are most frequently absent (Figs. 5c and 5d); in 173 of 450 extremities (38 per cent) lymph glands were wanting, and in only 108 (24 per cent) was there more than one gland present. The lymph glands of this group receive afferent lymphatics chiefly from the following source areas: skin of the perineum, including the cutaneous anal area; scrotum, vulva; the medial aspect of the thigh, leg and foot; rarely from the glans penis, glans clitoridis, penile skin and praeputium clitoridis. The lymphatics draining these regions likewise have abundant anastomoses across the midline to the glands of the opposite side.

Zone 4, the inferolateral quadrant, may contain no glands or as many as 9. These glands may be either rounded or oval in shape. When of the latter form, they are so placed as to have their long axes extending in a vertical direction. They are grouped chiefly about the lateral accessory saphenous and the termination of the superficial circumflex iliac veins (Figs. 5a and 5b). The glands in this zonal group receive their afferent channels chiefly from the skin of the anterior, lateral, and posterior sur-

faces of the thigh, leg, and foot, from the skin of the caudal part of the gluteal region, and occasionally from the skin of the perineum.

Zone 5, the central or presaphenous region, immediately overlies the saphenofemoral junction (Figs. 5c and 5d). A single, inconstant gland was found in this region in 68 of 450 extremities (15 per cent). This central, or presaphenous gland, may receive afferent lymphatics directly from the skin of the scrotum and penis (including the glans) in the male, and the vulva (with the glans clitoridis) in the female. Additionally, it may receive wider perineal drainage, as well as channels from any of the other zones.

As a group, the superficial inguinal lymph glands are drained by means of efferent lymphatics chiefly into the external iliac group of glands, located along the course of the external iliac artery and vein. However, they may also empty into the deep inguinal glands, which are situated beneath the fascia lata in the femoral triangle (see hereinafter).

Examination of statistical data growing out of tabular study of the records, indicates that 10 lymph glands occur with great constancy (Fig. 2). The most constant individual gland encountered in the current series is one situated in the angle formed by the bifurcation of the lateral accessory saphenous from the great saphenous vein. This gland is absent in but 13.75 per cent of the cases. In the zone of this constant element, a single gland is present in 60.5 per cent of the cases studied, 2 glands in 22 per cent, and 3 in 3.5 per cent. Another gland which occurs quite constantly in the authors' series (in 70 per cent of the cases) is one situated lateral to the lateral accessory saphenous vein and the gland mentioned above. A single gland, but occasionally 2 or 3 glands (average, 2), are frequently encountered (71 per cent of extremities) in an area from 2 to 3 centimeters lateral to, and at the horizontal level of, the saphenofemoral juncture. A single gland, or a chain of nodes numbering up to 9 (average, 4), is most frequently encountered along the course of the superficial iliac circumflex vessels. Lymph glands are absent at the customary site of this chain in but 6 of the 450 extremities examined (1.33 per cent). A group consisting of from 1 to 7 glands (average, 2), is almost constantly located medial and superior to the saphenofemoral juncture, near the pubic tubercle. In this area glands are absent in but 9 per cent of the cases. In 183 cases (40 per cent) 1 gland is present; 2 are present in 144 cases (32 per cent), 3 in 58 (13 per cent), 4 in 15 (3.3 per cent), 5 in 4 specimens (1 per cent), 6 and 7 glands each in but a single case.

Before proceeding further with the discussion, it might be well to recall that certain regions of the foot and leg, namely the lateral aspect of the foot, the heel, and the posterior surface of the leg may drain directly into the popliteal glands. They are 2 to 4 in number, and are located in the more distal portion of the popliteal space, along the course of the posterior tibial and small saphenous vessels and near their junction with the popliteal vessels. When malignancies involve these areas, the popliteal as well as the inguinal glands should be excised.

c. Selected specimens. In order to establish the extent to which the inguinal glands vary in respect to number, relationship to superficial tributaries of the femoral vein, and to group-distribution, seven specimens have been chosen for illustration (Figs. 1, 3, 4a to 4c, 5a to 5d). Each is a pictorial record of a dissection.

SPECIMEN 1 (Fig. 1)

Here, as is invariably the case, the lymphatic glands are lodged in the deep membranous layer of the superficial fascia in the stratum with the saphenous vein and its tributaries. These structures become visible as soon as the superficial fat-bearing layer of the superficial fascia has been reflected; however, for full exposure, enucleation from the tissue of the deep layer is required. That is to say, they are imbedded in, and do not merely rest upon, the latter layer.

In this specimen the glands are large. Most of them are removed by greater than average distance from the saphenous vein and the fossa ovalis; none ascends to the level of the inguinal ligament. With the saphenous vein they outline a field of quadrilateral form.

The great saphenous vein enters the femoral vein at the distal end of the fossa ovalis as a

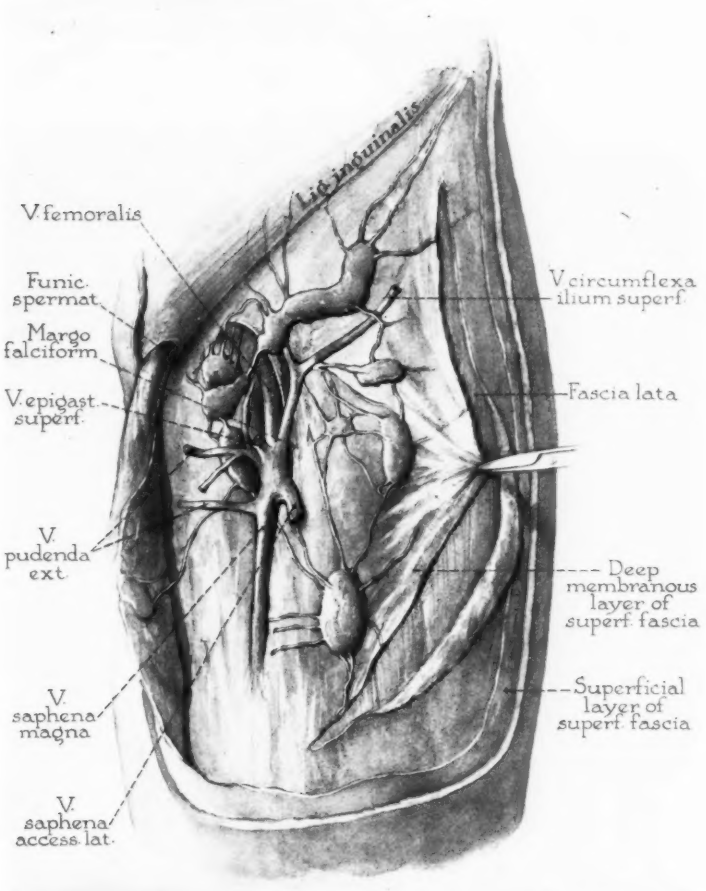

Fig. 1. Anterior femoral region; left thigh, specimen I. The superficial layer of the superficial fascia has been removed to reveal the deep layer with its contained inguinal lymph glands and the veins of the saphenous system to which the glands are intimately related. The deep layer has been incised and partially freed from the subjacent fascia lata.

short, thick trunk which almost immediately receives large superficial epigastric and superficial circumflex iliac veins. The first of the two external pudendals enters just above the point of confluence of the great saphenous trunk and the lateral accessory saphenous vein; the lower member of the pair terminates by entering on the medial aspect of the great saphenous vein distal to this confluens.

A large oval lymph gland is situated distal to the fossa ovalis, lying lateral to, and partially covered by, the lateral accessory saphenous vein (latter excised in Fig. 1 to expose the gland). Two lymph glands, one small and round, the other of medium size and oval, are situated 2 to 3 centimeters lateral to the saphenofemoral juncture. A single small, oval gland is located distal to the superficial circumflex iliac vein while a large, fused, or S-shaped gland, lies between this vein and the inguinal ligament. Two medium-sized, round lymph glands are located superior and medial to the

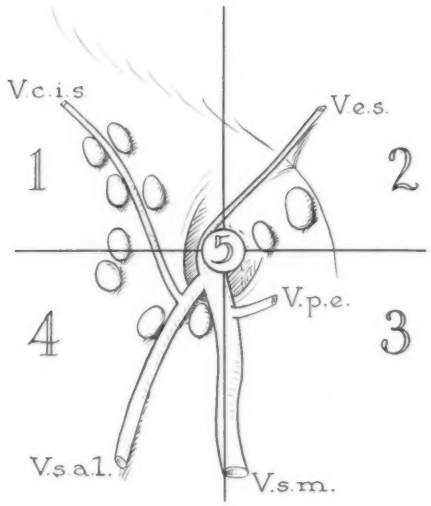

Fig. 2. Saphenous vein and tributaries in relation to the ten inguinal glands of most frequent occurrence. The glands are separable into five groups; four of the groups are bounded by lines which meet at the saphenofemoral junction; the fifth group would lie upon the vessels at the latter junction. *V.c.i.s.*, vena circumflexa iliaca superficialis; *V.e.s.*, vena epigastrica superficialis; *V.p.e.*, vena pudenda externa; *V.s.a.l.*, vena saphena accessoria lateralis; *V.s.m.*, vena saphena magna. Diagrammatic.

saphenofemoral juncture in the angle formed by the superficial epigastric vein (excised in Fig. 1) and superficial circumflex iliac vein. A single large oval gland is situated just medial to the saphenofemoral junction, being crossed on its anterior surface by the first of the two external pudendal veins. A single small oval gland lies 3 centimeters medial to the great saphenous vein, and 5 centimeters distal to the level of the saphenofemoral junction.

SPECIMEN II (Fig. 3)

On the right side three elongate glands are situated in the angle formed by the greater saphenous vein and its lateral accessory tributary. One large and two small lymph glands are situated along the course of, and just cephalad to, the superficial circumflex iliac vein. A large gland, apparently composed of three fused nodes, is placed immediately over the saphenofemoral juncture.

A single arterial branch, the external pudendal, emerges from the fossa ovalis and passes anterior to the great saphenous vein and its superficial epigastric tributary.

The great saphenous vein enters the femoral deep to the group of large, fused lymph glands. On its medial aspect it receives a large superficial epigastric branch, while on its lateral aspect it receives the fused common trunk formed by the lateral accessory saphenous and superficial circumflex iliac branches.

On the left side two lymph glands, one of them quite large, are situated within the angle of the great and lateral accessory saphenous veins. Three elongate nodes are placed along the course of the superficial circumflex iliac vessels; they receive numerous small branches from them. Two small, round glands are situated slightly superior and medial to the saphenofemoral juncture. Finally, a large slightly curved gland is located medial to the saphenofemoral juncture, in the angle formed by the great saphenous and superficial epigastric veins.

The external pudendal artery emerges from the fossa ovalis near its inferior margin and courses beneath the great saphenous vein to accompany the external pudendal vein. The superficial circumflex iliac artery escapes through a small foramen in the fascia lata just inferior to midportion of the inguinal ligament. Several small branches are given off to the adjacent glands as the artery accompanies its correspondent vein.

Near its juncture with the femoral vein, the great saphenous vein receives two large tributaries, one on each aspect, lateral and medial. Laterally the tributary vessel is the fused trunk of the lateral accessory saphenous and superficial circumflex iliac veins; the medial tributary is the superficial epigastric vein. The external pudendal vein reaches the femoral vein directly, entering the fossa ovalis from the medial side.

SPECIMEN III (Figs. 4a to 4c)

At the superficial level on the right side of this specimen all of the glands are situated near the saphenous vein, three on the lateral aspect of the vein, two on the medial aspect, two (one large, one small) on the superior aspect (Fig. 4a).

Only the superficial epigastric branch arises from the femoral artery within the fossa ovalis;

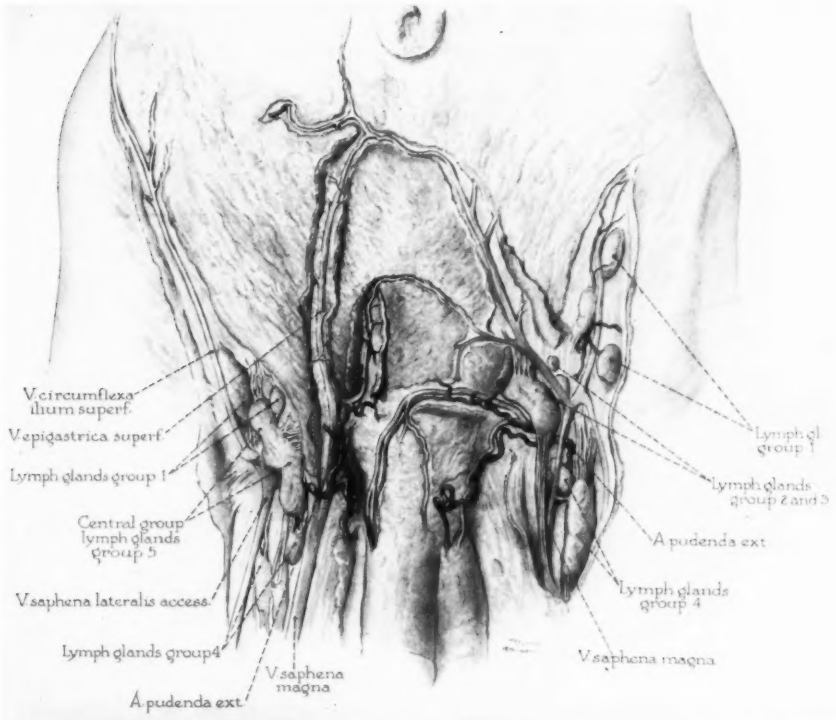

Fig. 3. Anterior femoral and adjacent inguinal and pudendal regions; right and left sides, specimen II. The superficial fatty stratum is here left intact except where it contains lymphatic glands and blood vessels. The vessels have not been transected (as they were in Fig. 1), but exposed *in situ* by removing the immediately surrounding adipose tissue. In this way the extent of the lower abdominal, proximal femoral and pudendal areas of vascular and lymphatic drainage is depicted, and the fascial level of the glands and vessels recorded.

the other two regular branches (superficial iliac circumflex and superficial external pudendal) emerge through small foramina in the fascia lata, each near the area of its ultimate supply.

The saphenous vein enters the femoral deep to the large superiorly placed lymph gland. On its lateral aspect the saphenous receives a large lateral accessory saphenous tributary and small veins from the superficial fascia and adjacent lymph glands. On the medial aspect the saphenous vein receives a superficial epigastric vein and two superficial external pudendal veins, the lower one of which enters by a common stem with a tributary draining the superficial tissue on the adductor side of the thigh.

On the left side, at superficial level, are two unusually large glands which almost encircle the saphenous vein at its termination; five lesser glands, two of which extend superolaterally along the superficial iliac circumflex vein, are also present (Fig. 4a). Efferent lymphatic vessels leave the upper member of the large pair of glands, to gain the pelvis by passing through a small hiatus in the fascia lata situated juts distal to the inguinal ligament. The margins of the fossa ovalis, the femoral artery and vein, are completely obscured by the lymph glands and the saphenous vein (cf. Figs. 4b and 4c).

A single superficial epigastric and a superficial external pudendal artery arise from the femoral within the fossa ovalis; the superficial iliac circumflex emerges through a separate

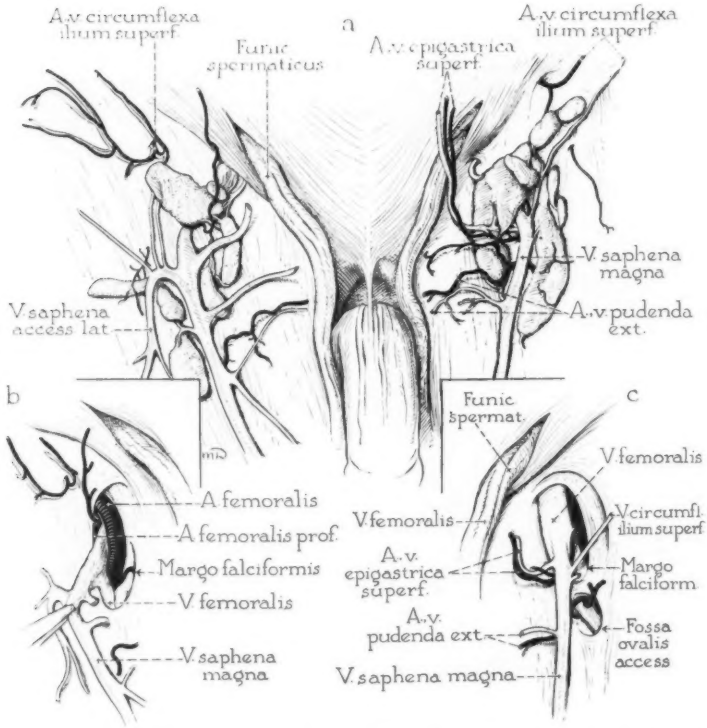

Fig. 4, a to c. Anterior femoral and adjacent regions; specimen III. a, Right and left sides. The bilaminar superficial fascia has been removed to expose the inguinal lymph glands as they lie in relation to the blood vessels. b and c, Right and left sides, respectively, of the same specimen. The lymphatic glands have been removed in order to expose the femoral vessels in the fossa ovalis and the branches of the artery and the tributaries of the vein to which the glands were related.

hiatus just inferior to the inguinal ligament, and sends some of its twigs to the lymph glands.

The saphenous vein receives the three regular tributaries (epigastric, iliac, pudendal) in addition to several small branches from the superficial fascia and adjacent lymph glands.

On the right side at deeper level (with lymph glands removed) the fossa ovalis and contained saphenous and femoral vessels are encountered (Fig. 4b). The regular relationship between femoral artery and vein is reversed, the femoral artery being located on the anteromedial aspect of femoral vein. The saphenous vein enters the femoral vein within an arterial crotch between the femoral artery on medial and superior aspects and the deep femoral branch on the lateral and inferior sides. The superficial epigastric artery emerges from the fossa ovalis, whereas the superficial circumflex iliac and external pudendal branches make their exit, nearby, through small hiatuses in the fascia lata.

On the left side, at comparable level, the fossa ovalis contains the femoral vessels in the regular relationship (Fig. 4c). The superficial epigastric artery arises from medial aspect of the femoral artery within the fossa ovalis; it passes inferior to the saphenofemoral juncture, and beneath the saphenous vein, before joining the corresponding vein. An accessory fossa ovalis is present just distal to the main orifice; it serves as the point of exit for the external pudendal artery. The latter then passes

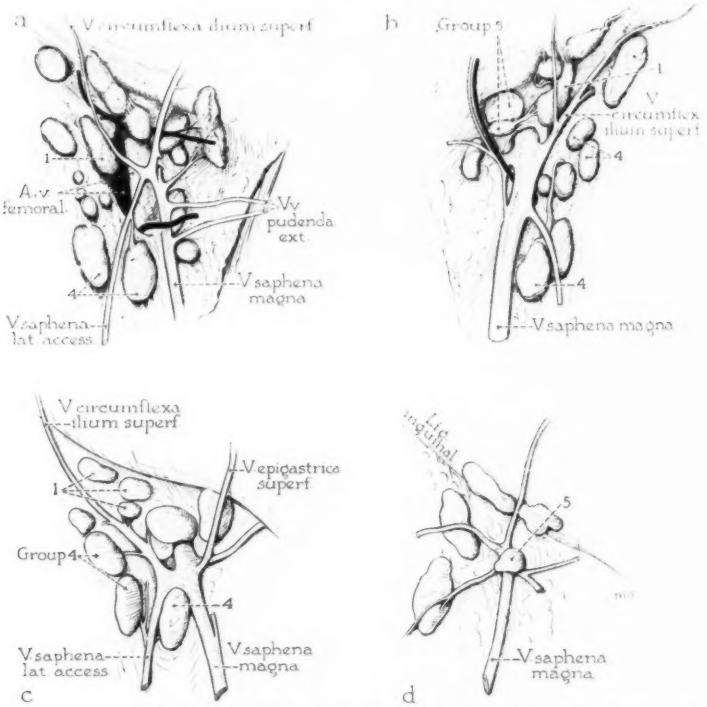

Fig. 5, a to d. Anterior femoral region. Types of arrangement of the inguinal lymph glands; specimens IV to VII. a, c, and d, Right groin; b, left groin.

beneath the saphenous vein to join the external pudendal vein.

SPECIMEN IV (Fig. 5a)

A single large oval gland is situated within the angle formed by the great and lateral accessory saphenous veins. Another large oval gland is located on the outer aspect of the lateral accessory saphenous vein at the same level as the preceding. A group of six glands, two large and oval and four small and round, are placed 1 to 3 centimeters lateral to the saphenofemoral juncture. A group of three large glands, round and elongate, are located along the course of the superficial circumflex iliac vein. Three glands are situated superior and medial to the saphenofemoral juncture in the angle formed by the superficial epigastric, external pudendal, and great saphenous veins. Two glands are situated medial and inferior to the saphenofemoral juncture. The first lies deep to the great saphenous vein at its juncture with the upper member of a pair of external pudendal tributaries; the second lies in the angle formed by the inferior member of the pair of veins and the great saphenous vein.

SPECIMEN V (Fig. 5b)

As in the preceding specimen, a single large gland is located in the crotch bounded by the great and the lateral accessory saphenous veins; lateral thereto is a gland of approximately the same size. Four smaller glands lie to the outer aspect of the saphenofemoral confluence. A single large gland is situated inferolateral to the superficial iliac circumflex vein, and five nodes lie in the triangular field between the latter vessel and the superficial epigastric vein. A single gland lies beneath the superficial external pudendal vein.

SPECIMEN VI (Fig. 5c)

Here the arrangement of glands essentially duplicates that occurring in the preceding case. Most of the nodes are situated lateral to the saphenous vein in a line prolonged cranialward to the inguinal ligament. A single gland is located between the great and the lateral accessory saphenous vein, one lateral to the lateral accessory saphenous vein, two inferolateral to the superficial iliac circumflex vein, and six in the area between the latter vessels and the superficial epigastric vein.

SPECIMEN VII (Fig. 5d)

In this specimen the glands are relatively few in number; they are widely separated and occupy unusual positions in relation to the saphenous tributaries and the inguinal ligament.

No gland is situated in the angle between the great saphenous and lateral accessory saphenous veins. One small gland is centrally placed over the site of the saphenofemoral junction. Two large glands occupy a lateral position—one beneath the accessory saphenous vein, the other under the superficial iliac circumflex vein. Two glands occupy the space between the latter vessel and an accessory superficial epigastric vein but are situated cranial to the line of the inguinal ligament.

Summarizing the above recorded observations (specimens I to VII) certain general conclusions of morphological nature may dependably be drawn.

Regarding relation to the strata in the anterior femoral region, it may be said that the superficial inguinal lymph glands are lodged in the deep layer of the superficial fascia. From this customarily membranous layer the overlying fatty, superficial layer of the pannicle of the proximal thigh is readily distinguishable and easily removable. Also passing through the deeper layer are the saphenous vein and its tributaries and the branches of the femoral artery which pass upward upon the inguinal wall or medialward to the pudendum. Because the glands and blood vessels are confined to a single fascial layer, they may be reflected *en masse* with that lamella—the floor of the dissection then being the fascia lata of the thigh. The latter fascia invests the femoral musculature; beneath it, in the femoral triangle and the adductor canal, are situated the large arteries and veins.[1]

Concerning the matter of general distribution, it might be said that in many specimens the inguinal lymph glands cover a subinguinal field which is roughly triangular in outline, with the base directed cranialward toward the inguinal ligament and the truncated apex pointed caudalward along the great saphenous vein. This would be an expected form, since the saphenous tributary pattern, among the elements of which the glands are nested, is itself triangular in outline—the great saphenous being apical, the pudendal, epigastric and iliac veins fanning out toward a basal portion. However, since two glands commonly lie side-by-side distally, at the "apex," the field might more graphically be described as being quadrilateral in outline (Figs. 2 and 3, 5a to 5c). Within this area, in the proximal part of the anterior femoral region, the lymph glands are not only arranged around and between the veins of the saphenous system, but bear generally predictable relation to the chief vein (great saphenous) and to the tributaries thereof (superficial epigastric, etc.). In general terms the following statements may be made: the glands are much more likely to be concentrated than dispersed; they are more likely to lie in the sulcus just distal to the inguinal ligament and along or between veins than they are to rest upon the ligament or under or upon the veins; that they more commonly spread superolaterally toward the anterior superior spine of the ilium than medialward toward the scrotum or labium; that, preponderantly, the glands are to be found within the three crotch-shaped areas bounded by the great saphenous, the lateral accessory saphenous, the superficial iliac circumflex and the superficial epigastric veins.

The individual lymph glands of the superficial inguinal region vary considerably in size. In a study of 50 consecutive extremities, glands vary from less than 0.6 square centimeter to greater than 10 square centimeters

[1]It should be understood that lesser blood and lymph vessels pass through the superficial fatty layer to the deep aspect of the skin, and through the fascia lata, by small hiatuses, into the musculature. The presence of these does not materially alter the general concept of position.

in surface area. In general, the lymph glands in zones 3 and 4 tend to be somewhat larger than those in zones 1, 2, and 5. These differences in size are, however, not constant; large and small glands are often found in zonal association, and either kind may be found in any zone of an individual thigh. The average size of the outline of glands in the several zones is as follows: zone 1, 0.75 square centimeter; zone 2, 0.87 square centimeter; zone 3, 1.37 square centimeters; zone 4, 1.75 square centimeters; zone 5, 1 square centimeter in area. The lymph gland which is so regularly located in the angle formed by the great saphenous vein and its lateral accessory branch is consistently larger and more prominent than its mates.

3. DEEP INGUINAL GLANDS

a. Number, size. The deep glands are smaller, as a lot, than the superficial. Their numbers vary, but usually they form an almost continuous chain, separated only for reasons of topographical convenience, from the iliac glands of the pelvis.

b. Location and arrangement. The glands follow the course of the femoral and deep femoral artery and vein. This means that they are subjacent to the fascia lata and chiefly in the femoral triangle. They may extend distally into the adductor canal; proximally the chain is prolonged beneath the inguinal ligament to merge with the members of the external iliac set.

The deep glands are lodged in the fatty tissue of femoral sheath. As already described and figured by McVay and Anson (1940), this adipose layer lies within the membranous tube which is regularly described as the femoral sheath. The membranous layer is a derivative of the abdominal and pelvic fascial layers—from the transversus and iliopsoas muscles, respectively. It is carried downward into the thigh, beneath the inguinal ligament, as the external iliac vessels become femoral (McVay and Anson, Fig. 5). Within this truly fascial sheath is situated the adipose layer; the latter is a derivative of the subserous (retroperitoneal) layer of the abdominopelvic cavity (McVay and Anson, Fig. 7). Housed within this fat-filled stratum of connective tissue, the glands are simply clustered about the femoral vessels (Fig. 7). The most constant and usually the largest member of this deep chain of nodes is the gland of Rosenmüller or Cloquet situated in the femoral canal beneath the inguinal ligament and medial to the vein. They are not separable into groups, since there exist neither femoral arterial rami nor corresponding venous tributaries which might serve as dependable boundaries for zones. Moreover, local concentrations of glands do not occur; the glands surround the femoral vessels in a scheme of rather even distribution. Consequently, a precise cataloguing of their relationships is not possible.

Summarizing these observations, it may be said that the deep glands, in being clustered about the large vessels within the adipose stratum of the femoral sheath, are arranged in the form of a chain; from one specimen to another they exhibit no marked variation in grouping or important difference in number. Usually they are of small or of medium size.

4. ILIAC (PELVIC) GLANDS

The iliac glands are associated with the external iliac, hypogastric (internal iliac) and common iliac blood vessels, and are correspondingly named. Those distally placed are continuous with the nodes of the inguinal set, while the glands situated proximally are continuous with the aortic (lumbar) nodes—the three sets being separable only upon topographical basis. In regard to number and position they conform to the standard descriptions.

The external iliac nodes are 8 to 10 in number, the hypogastric usually 8, the common iliac glands 4 to 6. The glands of the three sets are found chiefly along the sides of the vessels. Of the external iliac group, a single gland may rest upon the medial aspect of either artery or vein, or in the sulcus between the vessels; the hypogastric glands are similarly related to the hypogastric vessels and their larger arterial branches and venous tributaries; of the common iliac set, 1 or more may be partially concealed by the vessels (i.e., lie dorsal to them), and an equal number appear below the bifurcation of the aorta, upon the fifth lumbar vertebra. All of the iliac and

hypogastric nodes are likely to be of moderate size, and bean-shaped; they are not as variable in size as are those of the inguinal sets. They are imbedded in the somewhat fatty retroperitoneal (subserous) tissue which forms a lamina between the peritoneum and the parietal fascia.

In being relatively constant in number and situation, they do not require further anatomical description. By the same token, their surgical removal is simpler—once pelvic exposure has been made—than is extirpation of the glands in the femoral triangle.

Surgical Considerations

General

It is believed that the anatomical observations hereinbefore recorded furnish the basis for a reasonable surgical technique in the extirpation of the inguinal and iliac lymph nodes. Thus, knowledge of the expanse of the area occupied by the superficial glands establishes the dimensions of the gland-bearing lamina to be removed in surgery; information concerning the lodgement of these glands in a definite fascial layer indicated that such a plate of tissue may be removed *in toto*, employing natural cleavage planes to guide excision; demonstration of the abundant presence of such glands in the area points to the necessity of extirpation. Additionally, concentration of the deep glands in the adipose lamella of the femoral sheath, suggests the possibility of simple circumvascular excision of the glands bearing tissue within the confines of the femoral triangle, deep to the fascial sleeve (fascia lata) of the thigh. Continuity of this tissue with the subserous layer in the pelvis further suggests that removal of the closely related external iliac, hypogastric, and common iliac glands, situated along the brim and in the hollow of the pelvis, can be accomplished by an extraperitoneal approach. Since, in the last phase of the surgical procedure the structure of the inguinal wall is disturbed in a way similar to that obtaining in hernial repair, steps prescribed earlier for reconstruction of the inguinal canal would seem suitable.

The application of these observations will be presented in detail, following brief discussion of the circumstances which render surgery necessary.

Radical groin dissections are indicated in the treatment and removal of cutaneous and superficial malignancies occurring in the external genitalia, lower extremities, umbilical and infraumbilical abdominal wall, gluteal regions, perineum, and cutaneous anal region. A number of excellent techniques have been described for the radical excision of the superficial inguinal, deep inguinal and external iliac lymph nodes by Taussig (1940), Young (1931), and Pack and Rekers (1942). Pack believes that radical groin dissections are indicated routinely in the treatment of melanomas of the lower extremity, genitalia, perineum and abdominal wall and in epitheliomas of the scrotum and vulva even in the absence of palpably enlarged nodes.

Pack and Rekers have recommended an extensive removal of skin, subcutaneous fasciae and fascia lata in their technique of radical groin dissection. Taussig, in his modified Bassett operation, has been somewhat less radical in the amounts of tissue to be excised. The present authors feel that there is needed a more explicit and detailed description of the amount of superficial fasciae, skin, and fascia lata to be excised. Since the superficial inguinal lymph glands are the nodes primarily concerned in the lymphatic drainage of the areas herein described, their excision should be accurate and painstakingly complete. The present technique has been prepared in an attempt to clarify and simplify techniques previously described.

Authors' Procedure

Specimen VIII (Figs. 6 to 8)

A vertical, slightly oblique skin incision 8 to 10 inches in length is used. It passes diagonally across the inguinal (Poupart's) ligament from a point 2 inches medial to the anterior superior iliac spine and 1 to 2 inches above the inguinal ligament to a point on the anteromedial aspect of the thigh over the adductor canal (Fig. 6a, in which shaded areas illustrate the distance to which the skin flaps should be undermined). The flaps, bounded by the incision, should be thin, but in adipose subjects may contain a moderate amount of subcutaneous fat.

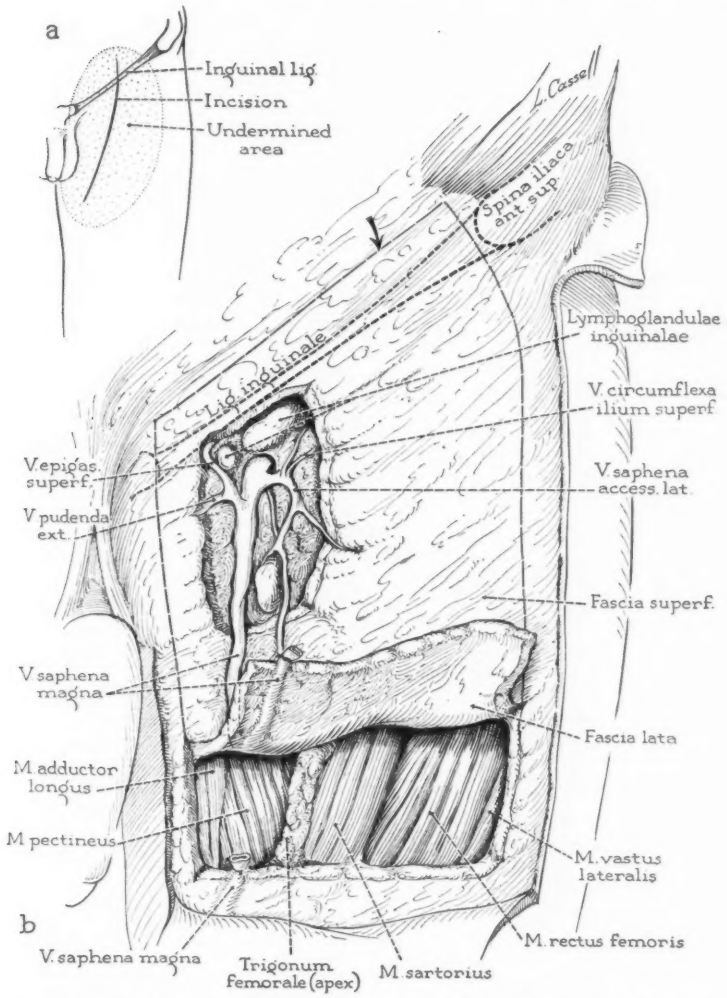

Fig. 6, a and b. Technique of surgical exposure of the inguinal lymph glands, carried out on an anatomical basis; specimen VIII. a, Direction and extent of surgical incision. Shaded regions indicate the extent to which skin flaps should be undermined. b, Surgical procedure, continued. Showing the structures contained in the quadrilateral "block" of tissue excised in the radical extirpation of the glands, and the associated veins and the fascia in which the superficial glands and vessels are imbedded. The quadrilateral area is outlined, its superior limit marked by an arrow. Proximally, in the area of the fossa ovalis (saphenous opening), the bilaminar superficial fascia has been removed, exposing the deep fascia (fascia lata); distally, just beyond the apex of the femoral triangle, both superficial and deep layers have been incised and turned upward together, exposing the subjacent musculature.

Continuing in the procedure, here illustrated by dissections of selected specimens, the skin over the anterior surface of the upper thigh and lower abdomen is to be excised. Similarly, the superficial fascia and the fascia lata are to be removed (Fig. 6b, block of tis-

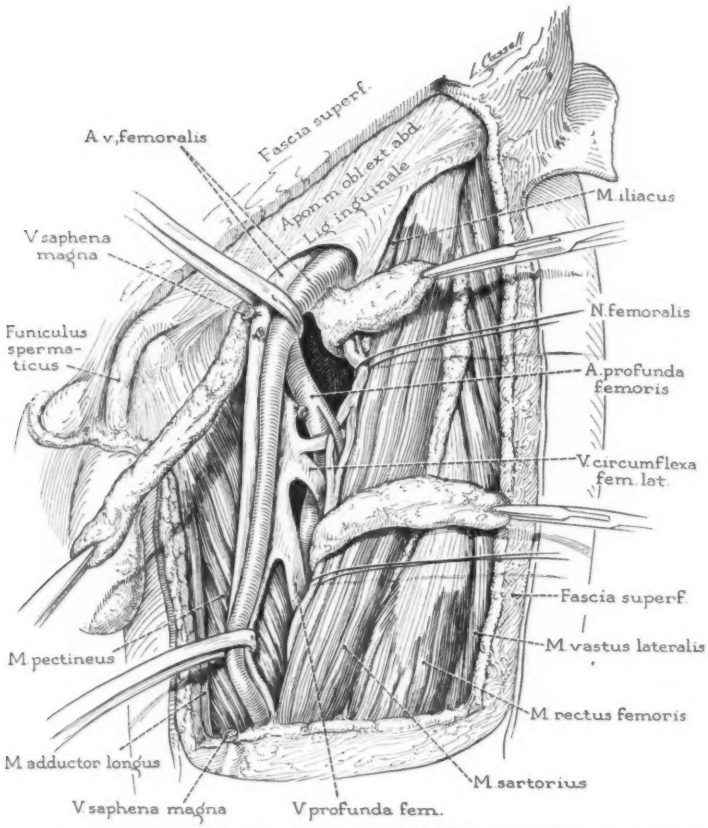

Fig. 7. Procedure, continued; same specimen (VIII). Illustrating the method of removing the deep inguinal glands, by opening the fibrous layer of the femoral sheath and excising the gland-bearing fatty layer (retracted in several portions) which surrounds the femoral vessels.

sue outlined by dotted lines). The quadrangular block is 5 inches wide and 8 inches long. In the region of the fossa ovalis the superficial fatty tissue, overlying the great saphenous vein and its tributaries and the superficial inguinal lymph glands, is removed. The dissection is begun at the lower end of the quadrilateral block, the great saphenous vein being doubly ligated and severed. Then the incision is carried deeply, to the level of the underlying musculature of the thigh. The block removal of these tissues continues in a cephalad direction.

In the next step of the procedure the quadrilateral block of tissue, consisting of the superficial and fascial layers, with contained saphenous vessels and all superficial inguinal lymph nodes is excised, exposing the underlying musculature of the thigh in the femoral triangle (Fig. 7). Beginning at the apex of the femoral triangle, the femoral sheath, with the contained gland-bearing adipose tissue, is progressively removed; in this way, the femoral vessels, their circumflex and deep branches, and the femoral nerve are entirely freed of their surrounding fibroadipose tissues. The several muscular rami (to the pectineus, iliopsoas, quadratus femoris, and adductor muscles) should be ligated and severed in order to facilitate this phase of the surgical dissection

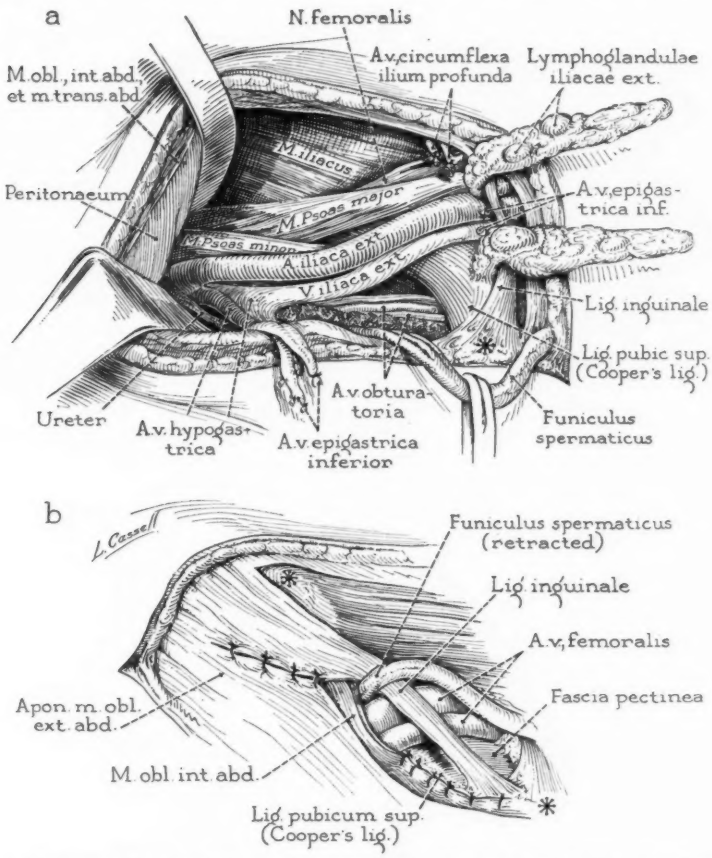

Fig. 8, a and b. Surgical procedure, concluded; same specimen (VIII). Showing the method, a, by which the dissection is carried into the pelvis preparatory to removal of the iliac lymph glands, and the means, b, of closure of the inguinal incision, through utilization of the superior pubic ligament as a line for aponeurotic anchorage. Asterisk in a marks the site of the pubic tubercle, as does the lower asterisk in b; upper asterisk in the latter figure is on the anterior superior spine of the ilium.

(deep branches and tributaries demonstrated in Fig. 7 by retraction of the femoral artery and vein; gland-bearing tissue mobilized).

In preparation for the next stage in extirpation, the external oblique aponeurosis is cut, in the direction of its fibers, from the subcutaneous inguinal ring to a point approximately 1 to 2 inches lateral to the abdominal inguinal ring (Figs. 8a and 8b). The spermatic cord (or the round ligament) and the inguinal canal are thoroughly cleaned of the investing connective tissue—in which latter are contained lymphatic vessels. The transversalis fascia is freed from its attachment to the inguinal ligament and the subjacent iliopsoas and pectineus fasciae. By means of blunt dissection, the peritoneum is raised from the lateral wall and floor of the pelvis and retracted cephalad, to expose the common iliac vessels to a point well above their bifurcation and the point at which they are crossed by the ureter. The obturator nerve and vessels on the lateral pelvic wall are also clearly exposed. To facilitate this exposure it is necessary to ligate doubly

and sever the inferior epigastric and deep circumflex iliac branches of the external iliac artery and the corresponding veins. The spermatic cord, with the contained spermatic artery, pampiniform plexus and ductus deferens is to be retracted medially by means of a Penrose drain. Starting superiorly near the bifurcation of the abdominal aorta, the investing sheaths of the common and external iliac and hypogastric vessels, together with the surrounding gland-bearing fibroadipose tissues, should be stripped away down to the level of the inguinal ligament. The obturator nerve and vessels, also made visible, are to be freed of all the fibrous tissue in which they are imbedded. Here care should be taken to avoid injury to anomalous obturator vessels arising from the external iliac artery and vein (see Ashley and Anson, 1941).

In closing the inguinal portion of the surgery the hernial technique devised by McVay and Anson (1942) has been successfully employed in the senior author's cases. The fused aponeurotic portions of the internal oblique and transversus abdominis muscles and the underlying transversalis fascia are approximated to the superior pubic (Cooper's) ligament by means of six steel wire sutures (Fig. 8b). This approximation is carried lateralward, from the pubic tubercle to the medial edge of the external iliac vein. The external oblique aponeurosis, which was previously split in the direction of its fibers, is next reconstructed in its lateral portion by means of interrupted steel wire sutures. At this stage the deeply situated external iliac artery and vein are clearly visible, and the spermatic cord lies free on the anterior surface of the proximal thigh. In completing this repair, the spermatic cord should be placed in the trough-like furrow created by approximation of the so called conjoined tendon and superior pubic ligament. The external oblique aponeurosis is then restored above the cord, in order to reconstruct the subcutaneous inguinal ring at a point just medial to the pubic tubercle. If the vascular supply to the widely undermined skin flaps appears adequate, these flaps may be approximated. Penrose drains are placed (to promote drainage) at either end of the incision. If however, viability of the flaps appears doubtful, then wide excision of the skin flaps is carried out and closure effected through the use of a broad-based pedicle flap and a split thickness graft. Postoperative refrigeration has also proved of value in preserving the viability of the cutaneous flaps.

SUMMARY

On the basis of an anatomical study of 450 dissection room specimens, data on the size, arrangement and number of the inguinal and associated pelvic glands have been presented, with the object of placing these morphological facts upon schematic and statistical bases. Certain types were found to predominate in relation to regular tributaries of the saphenous vein and to the femoral and external iliac vessels. Additionally, several representative specimens have been illustrated and described in detail, in order to account more satisfactorily for the anatomical conditions encountered in individual bodies.

A surgical technique has been described, together with drawings of the steps involved. This procedure is the outcome not only of the antecedent observations on anatomic arrangement of the glands and associated structures, but also of the actual surgical employment of the selected method.

REFERENCES

1. Ashley, F. L., and Anson, B. J. Am. J. Phys. Anthrop., 1941, 28: 381-395.
2. Bardeleben, K. von. Handbuch der Anatomie des Menschen. Jena: Fischer, 1911.
3. Daseler, E. H., Anson, B. J., Reimann, A. F., and Beaton, L. E. Surg. Gyn. Obst., 1946, 82: 53-63.
4. McVay, C. B., and Anson, B. J. Anat. Rec., 1940, 76: 213-231.
5. Idem. Surg. Gyn. Obst., 1942, 74: 746-750.
6. Pack, G. T., and Rekers, P. Am. J. Surg., 1942, 56: 545-565.
7. Rouvière, H. Anatomy of the Human Lymphatic System. Translated by M. J. Tobias. Ann Arbor, Mich.: Edwards Bros. Inc., 1938.
8. Taussig, F. J. Treatment of Tumors of the Vulva from Treatment of Cancer and Allied Diseases. Vol. II, by Pack, G. T., and Livingston, E. M. New York: Paul B. Hoeber, Inc., 1940.
9. Young, H. H. J. Urol., Balt., 1931, 26: 285-294.

INTRA-ARTERIAL TRANSFUSION

Experimental and Clinical Considerations

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THE restoration of blood volume and pressure in the treatment of acute hemorrhage and traumatic shock is a fundamental surgical procedure. The rapidity with which this is accomplished will determine in large part the immediate course and prognosis, particularly with regard to cerebral function and the prevention of anuria and myocardial anoxia. The procedures currently in use are concerned primarily with replacement of blood volume rather than restoration of pressure, which occurs secondarily. The purpose of this paper is to present experimental and clinical data concerning a method for the simultaneous rapid restoration of blood volume and pressure, utilizing the intra-arterial route of administration.

The administration of fluids intra-arterially was reported as early as 1937. Hypertonic solutions of sodium chloride were used in the treatment of shock by Davis and associates. Kendrick and Wakim, in their work on dogs, found this solution to be deleterious in that the rise of blood pressure was transitory and the animals would not respond to subsequent injections. The intra-arterial method for administration of blood was employed with success by I. A. Birillo, his report appearing in a Russian journal in 1939. In this country, the intra-arterial route for the infusion of plasma and blood was first used by Kohlstaedt and Page, upon the suggestion of Colonel Sam F. Seeley, Medical Corps, U. S. Army. Their clinical procedure was based upon animal experimentation in which they compared the efficacy of intra-arterial and intravenous infusion of blood in experimental shock. Standardized hemorrhagic shock was produced in dogs by arterial bleeding until a mean arterial pressure of 50 millimeters of mercury was reached. This pressure was maintained for a period of 90 minutes and then cautiously reduced to 30 millimeters of mercury and kept at that level for 45 minutes. In one group, the total volume of blood removed was returned intra-arterially and intravenously. The results showed a survival rate of 100 per cent for the intra-arterial group as compared with 75 per cent for the intravenous group. In a second group, in which only half the blood removed was reinfused, 75 per cent of the intra-arterial group survived, whereas only 30 per cent of the intravenous group recovered. Clinically, infusion of solutions other than whole blood caused sloughing of skin in the area supplied by the artery, presumably due to prolonged ischemia.

Later work by Glasser and Page, evaluating prognostic signs in hemorrhagic shock, further demonstrated the efficiency of intra-arterial infusion. Moreover, they found that when large infusions of blood are required to restore pressure and volume, the prognosis is poor; the same is true for a falling pressure upon termination of the infusion. These authors observed the effect of ouabain upon the survival rate of animals in shock receiving intra-arterial transfusion. The increased survival rates with the use of this rapidly digitalizing drug suggests that the drugs of this group might have a beneficial effect upon the myocardial depression seen in prolonged shock (10).

Shaffer has recently reported that in attempting the administration of transfusions intravenously under pressure, the needle was occasionally placed within the femoral artery and the infusion completed with no untoward results. Kay and Hacker described the successful use of intra-aortic transfusion by direct puncture during the course of an exploratory thoracotomy for control of hemorrhage from a lacerated internal mammary artery.

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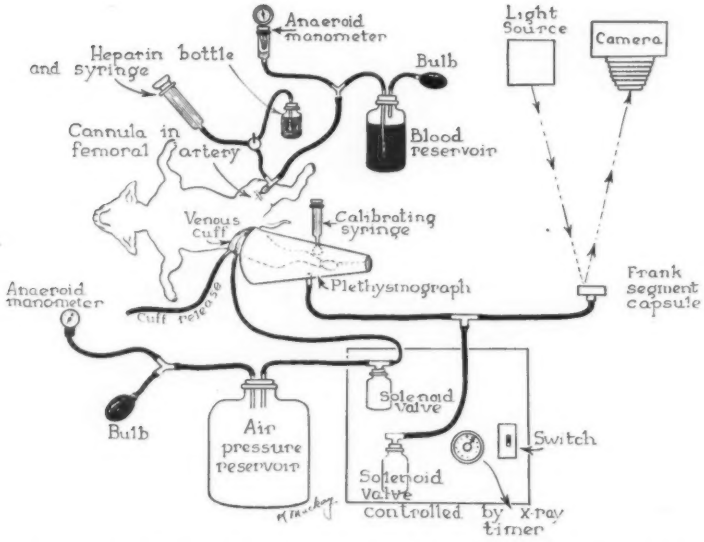

Fig. 1. Diagrammatic sketch of equipment used to measure blood pressure and flow in dogs while a state of hypotension is produced. Plethysmograph, solenoid valves for control of cuff inflation and elimination of cuff artefact, and system of optical recording are shown. One limb of the dog is shown with femoral artery cannulated for hemorrhage and reinfusion.

Controlled hypotension by arterial bleeding has been used by Gardner to attain a relatively bloodless field in certain neurosurgical procedures. Blood is removed by cannulation of a peripheral artery and replaced intra-arterially at will during or upon completion of the procedure.

In the light of this previous work, intra-arterial transfusion appeared to have a place in the treatment of shock. Accordingly, the demonstration of the effectiveness of the intra-arterial transfusion experimentally has led to its clinical application.

The transfusion of blood intra-arterially is based upon the hydraulic principles of Archimedes. Under a pressure greater than that of the mean arterial blood pressure an infusion will enter the arterial system. The increased pressure and flow will be conducted throughout the entire system, as far proximally as the aortic valves. There will be an immediate increase in arterial pressure and blood volume. Under the conditions of shock, in which there is a lowered blood pressure, decreased blood volume, and reduced tissue perfusion, an intra-arterial infusion will act to restore to normal levels all three deficiencies.

EXPERIMENTAL PROCEDURE

In the experimental work with intra-arterial and intravenous transfusions, an attempt was made to correlate not only blood pressure changes and visible response with the route of administration, but to secure some quantitative measurement of tissue perfusion. Blood flow to an extremity was selected as a criterion for determining changes in the peripheral blood flow, on the premise that since this flow is restored late in the correction of hemorrhagic shock, flow to vital centers probably has already been restored.

In the dog, blood flow to a hind limb was measured after the method of Eckstein and associates, a small air plethysmograph being used; the measurements were recorded optically with a large segment capsule (Fig. 1.). Arterial blood pressures were recorded optically, by means of Hamilton manometers. The

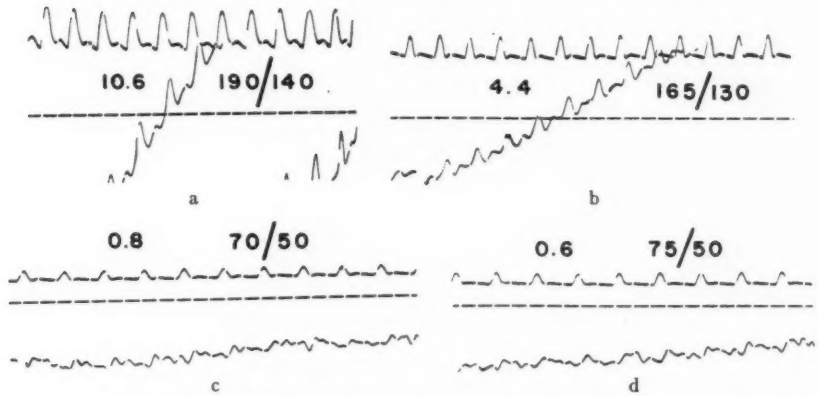

Fig. 2. Blood pressure and blood flow tracings demonstrating progressive vasoconstriction in hemorrhagic hypotension and shock in dogs. Blood pressure is recorded optically, using Hamilton manometers; the readings are in millimeters of mercury. Blood flow curves are superimposed on the arterial tracings. The values indicate cubic centimeters of blood per 100 cubic centimeters limb per minute. Time: 0.2 second. a, Normal; b, hemorrhage begun; c, shock—10 minutes; d, shock—45 minutes.

following procedure was used: adult dogs, weighing 10 to 20 kilograms were anesthetized with intravenous sodium pentobarbital (30 milligrams per kilogram of weight). One hind limb was sealed in the plethysmograph with melted printer's mica compound. The opposite femoral artery was cannulated for controlled hemorrhage, pressure readings, and the reinfusion of blood. In some experiments, other arteries such as the carotid or radial were cannulated for pressure determination. After a basal period of 20 to 30 minutes, normal blood pressures and flows were recorded. The animals were then bled rapidly into a bottle containing 2.5 per cent citrate solution until the mean arterial pressure reached 50 millimeters of mercury. The blood pressure was kept at this level by repeated small hemorrhages. During the period of hemorrhage and the ensuing period of hypotension, serial blood pressure and flow measurements were made (Fig. 2).

Hemorrhagic hypotension was maintained for intervals varying from 30 to 75 minutes. At the end of this interval, all the blood removed was reinfused; one group of animals received the infusion by the intra-arterial route, another intravenously. In the intra-arterial group, the blood was reinfused at a pressure approximately 50 millimeters of mercury greater than the mean blood pressure; air pressure above the blood in the infusion reservoir was used. Infusion rates by this route averaged about 100 cubic centimeters per minute.

The intravenous infusions were allowed to flow by gravity at a rate which was substantially greater than that used in the routine clinical administration of blood, and which was considered to approach the maximum pressure

TABLE I.—RESULTS OF REINFUSION OF BLOOD IN DOGS BY INTRA-ARTERIAL AND INTRAVENOUS ROUTES

Animal No.	Normal values	Time in shock min.	Shock values	Time for recovery min.	Recovery values	Result
Intra-arterial transfusion:						
7	6.6 140/105	45	0.8 60/40	10	6.3 145/90	Survived
22	11.4 170/130	75	0.3 55/35	8	5.3 165/125	Died-2 Da.
35	11.5 162/120	60	0.8 78/58	7	9.0 150/100	Survived
53	10.6 190/140	45	0.6 70/50	4	9.3 190/120	Survived
72	13.9 115/90	30	0.3 55/40	7	10.4 110/85	Survived
Intravenous transfusion:						
7	10.6 170/140	30	0.6 92/58	28	5.9 125/82	Survived
21	13.4 130/92	60	1.6 65/44	38	6.5 125/90	Survived
61	6.5 116/96	45	1.4 60/50	30	5.8 98/74	Survived
*81	13.9 130/90	30	1.6 55/40	18	12.2 130/90	Survived

*Rapid intravenous infusion. 500 c.c. returned in 6 minutes.

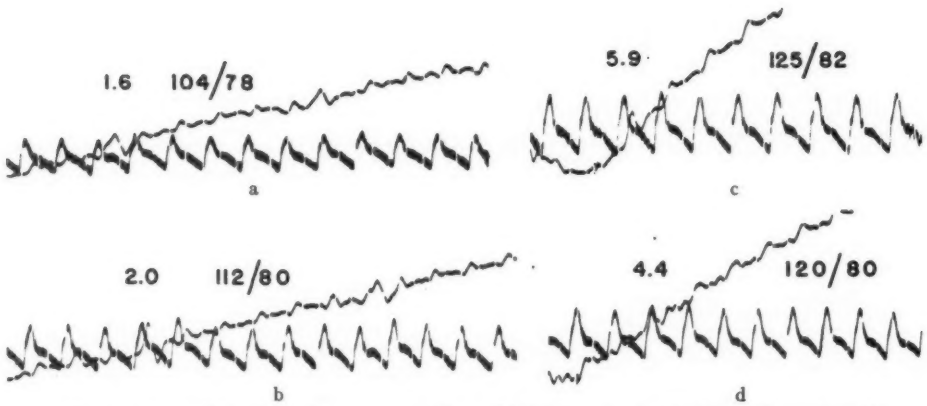

Fig. 3. Restoration of blood pressure and flow with intravenous transfusion in dog—480 cubic centimeters of blood given in 28 minutes. a, Transfusion—5 minutes, 100 cubic centimeters; b, 10 minutes, 200 cubic centimeters; c, transfusion completed, 28 minutes; d, 60 minutes after transfusion begun.

permissible to avoid right heart congestion. These averaged 10 to 25 cubic centimeters per minute. Too rapid an intravenous infusion, as shown by Kohlstaedt and Page, may cause a sharp rise in intrathoracic venous pressures and signal impending cardiac failure.

Pressure and flow determinations were made throughout the infusion period and for varying intervals thereafter up to 1 hour to determine constant or variable trends. The results are shown in Table I.

Typical blood flow and pressure measurements are shown in Figures 3 and 4, affording a comparison between the response to the alternate routes of administration.

DISCUSSION OF EXPERIMENTAL RESULTS

Basal arterial pressures and blood flow values in the anesthetized animal varied within fairly definite limits. In the dog, pressures varied from about 120/80 to 190/120 and were considered normal. Blood flows obtained after anesthesia of approximately 30 minutes to 1 hour yielded values which varied widely in different experiments (about 4 to 14 cubic centimeters blood per 100 cubic centimeters limb per minute) but which were generally constant for any one animal.

When hemorrhage was begun there was an immediate reduction in blood flow in the extremities and only a minimal drop in arterial pressures. After the removal of 200 to 250 cubic centimeters of blood from the average dog, arterial pressure began to decline and blood flows dropped off sharply until low values (0.5 to 0.8 cubic centimeters blood per 100 cubic centimeters limb per minute) were obtained.

This reduction in extremity blood flow was representative of the generalized vasoconstriction secondary to the sudden decrease in blood volume. Others have shown that along with a reduction in cardiac output there is also a diminution in blood flow through the kidneys, coronary vessels, and other organs and tissues.

When an intra-arterial transfusion was initiated at a pressure approximately 50 millimeters of mercury greater than the animal's mean arterial pressure, changes in pressure and extremity blood flow were noted immediately. There was an almost instantaneous rise in pressure throughout the arterial system, as noted by recording the pressure in arteries some distance from the site of transfusion, for example the radial or carotid. Blood flows rose sharply and reached normal pre-shock values in an average of about 7 minutes. Some were restored as quickly as 4 minutes. The animal's appearance improved, the pallor of the mucous membranes and skin disappeared, cyanosis faded, and respiration became slower and deeper. Upon discontinuing the intra-arterial transfusion, arterial pressures and extremity blood flows were maintained indefinitely and recovery ensued in all instances.

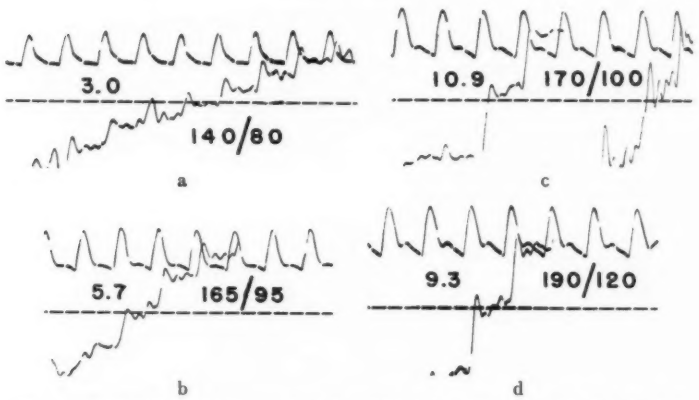

Fig. 4. Restoration of pressure and flow with intra-arterial transfusion in dog—500 cubic centimeters of blood given in 6 minutes. The time required to restore the pressure and flow is 4 to 5 times less than that required by the administration of blood intravenously. a, Intra-arterial transfusion, 1 minute 125 cubic centimeters; b, 3 minutes 300 cubic centimeters; c, transfusion completed, 6 minutes, 500 cubic centimeters; d, 45 minutes after transfusion begun.

Following intravenous transfusions, recovery was considerably slower, requiring a period approximately four times longer than that required after intra-arterial transfusion. There was also a tendency for blood pressure and flow to be maintained at a lower level than normal after the transfusion was completed.

In general, these results were in agreement with the more extensive work of Kohlstaedt and Page, but differed in that the period of hypotension in these experiments was shorter and in each instance all the blood removed was reinfused.

All of the animals survived indefinitely, except for one which died of distemper 2 days after an intra-arterial experiment. No ill effects were observed following either procedure. In one instance (dog 7, Table I), a comparison of the two methods of transfusion, carried out several weeks apart on the same animal, is afforded.

CLINICAL APPLICATION

The clinical application of the intra-arterial transfusion at Emory University Hospital and Grady Memorial Hospital has followed the technique developed experimentally by Kohlstaedt and Page. The dramatic results demonstrated in the laboratories on animals in experimental shock led to its introduction clinically.

The apparatus is simple and easily assembled from materials found in any hospital blood bank (Fig. 5). The blood is contained in a 1000 cubic centimeter Kelly bottle, from which it flows through a glass Y to the cannulated artery and an an roid manometer unit. Controlled air pressure from a sphygmomanometer bulb applied above the blood in the reservoir permits the pressure within the entire system to be maintained at any desired level.

The aneroid manometer unit provides an interface between the sterile and unsterile parts of the apparatus, as shown in Figure 5. The sterile rubber stopper with attached finger from a surgeon's glove is placed loosely in the glass tube. A 2.5 per cent sodium citrate solution is poured into the reservoir and allowed to fill the tubing. When the level of the solution has risen to 2 centimeters in the manometer tube, the rubber stopper is pressed in firmly. An increase in hydraulic pressure within the system will be transmitted to the air above the solution and be recorded by the aneroid gauge.

The apparatus, except the rubber bulb and aneroid gauge, is wrapped as a unit on a tray and autoclaved. Prior to use, the entire system is assembled, clamped in place with double-end clamps, and filled with citrate solution. Blood is transferred from the collecting bottles by filtering through layers of sterile gauze.

TABLE II.—RESULTS OF INTRA-ARTERIAL TRANSFUSION IN CLINICAL CASES

Case Sex Age	Condition predisposing to shock	Blood pressure at beginning of transfusion	Blood pressure at completion of transfusion	Volume of whole blood transfused—c.c.	Time required for administration—min.	Artery used	Results
1 F 50	Septicemia with peripheral circulatory collapse	0	0	250 plasma	10	Radial	Died
2 F 40	Uterine hemorrhage	0	90/60	250	15	Radial	Survived
3 F 30	Craniotomy with operative hemorrhage	0	100/70	1000	40	Post tibial	Survived
4 F 12	Rupture of mycotic aneurysm	0	100/65	500	20	Radial	Survived*
5 M 55	Intestinal obstruction, neglected pulmonary tuberculosis	40/0	85/50	1500	45	Radial	Died
6 F 23	Placenta previa with hemorrhage	0	100/75	1000	50	Radial	Survived
7 M 40	Rupture of aneurysm	0	130/60	2000	40	Radial	Survived
8 F 36	Gunshot wound of the abdomen	60/30	130/70	1500	40	Radial	Survived
9 M 46	Secondary hemorrhage in perinephritic abscess	0	100/60	1750	30	Radial	Survived
10 M 53	Hemorrhage from gastrojejunal stoma	93/50	100/60	1500	120	Radial	Survived†
11 F 50	Nephrectomy for hypernephroma with operative hemorrhage	0 0	110/90 100/75	1000 1500	40 60	Radial Post tibial	Shock in 1 hour Survived‡
12 M 60	Transurethral prostatectomy with postoperative hemorrhage	0	110/60	1500	52	Radial	Survived¶

*Patient died 2 days later from secondary rupture of the aneurysm.
†Transfusion was given to stabilize blood pressure during an operative procedure in a patient with incipient shock and decreased blood volume.
‡Patient showed signs of shock 1 hour after termination of the first intra-arterial transfusion.
¶Patient died 5 hours later from a secondary hemorrhage.

The radial, dorsalis pedis, and posterior tibial arteries are used most frequently for intra-arterial transfusion. The vessel is exposed, and a small longitudinal incision is made in its wall, through which the cannula is introduced and directed proximally. A distal ligature is tied to prevent back bleeding. Any type metal or glass cannula of 14 or 15 gauge may be used. Upon release of the clamp behind the cannula the pressure within the patient's arterial system may be read immediately on the aneroid gauge.

Depending upon the pressure noted in the cannulated artery, the condition of the patient and the former blood pressure, if known, the pressure necessary for transfusion can be estimated. In patients with no perceptible blood pressure the transfusion should be initiated at a pressure of 50 millimeters of mercury. The previously estimated optimum pressure may be reached rapidly in successive increments of pressure.

The rapidity with which the transfusion will flow is dependent upon the differential in pressure between that in the reservoir and the patient's arterial system. As the patient's arterial pressure rises, there is a diminution in both velocity and volume of flow through the cannula, approaching zero as the pressures equalize. By maintaining a constant head of pressure in the transfusion reservoir, the arterial pressure can be controlled within narrow limits.

To date, 13 intra-arterial transfusions have been given (Table II). The case reports are

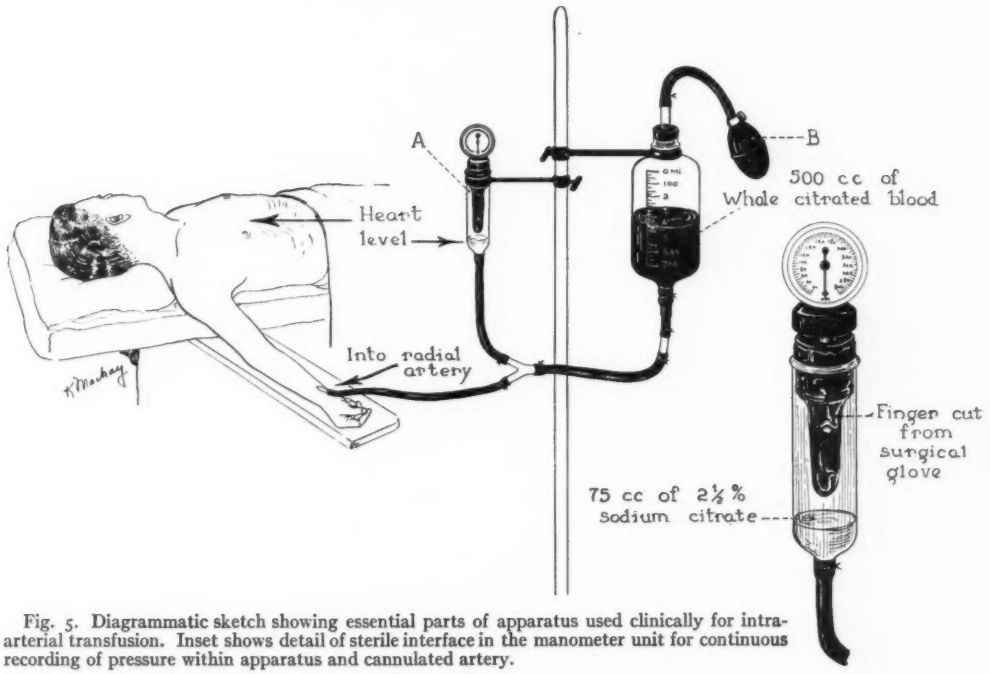

Fig. 5. Diagrammatic sketch showing essential parts of apparatus used clinically for intra-arterial transfusion. Inset shows detail of sterile interface in the manometer unit for continuous recording of pressure within apparatus and cannulated artery.

presented to illustrate the effects of the transfusions under different conditions.

CASE 1. A 50 year old woman with an overwhelming septicemia developed peripheral circulatory collapse and had no perceptible blood pressure. Although she was not considered a proper candidate for an intra-arterial transfusion, an attempt was made to restore her blood pressure by an infusion of 250 cubic centimeters of plasma in the right radial artery in 10 minutes. The patient showed no improvement and died despite all restorative measures attempted.

CASE 2. A 40 year old woman with a submucous leiomyoma of the uterus had lost a large amount of blood prior to admission to the hospital. During her stay in the hospital in preparation for operation, she had a brisk hemorrhage from the uterine cavity and developed profound shock with rapid pulse, loss of consciousness and no perceptible blood pressure. She received 250 cubic centimeters of blood in the left radial artery in 15 minutes with a dramatic rise in blood pressure to 90/60 and subsequent recovery from shock. A hysterectomy was later performed with no complications.

CASE 3. During a craniotomy performed on a 30 year old woman, the patient's blood pressure and pulse became imperceptible. With every known measure taken to restore her blood pressure she still did not respond. An intra-arterial transfusion of 1000 cubic centimeters of blood was given via the right posterior tibial artery. Although the transfusion was administered over a period of 40 minutes, there was immediate response; the patient's blood pressure rose to 100/70 and her pulse slowed to 130. The operation was successfully completed.

CASE 4. Following operation for a patent ductus arteriosus, this 12 year old female child developed a mycotic aneurysm. During operation for correction of the defect, the aneurysm ruptured. The patient rapidly lost a large amount of blood, leading to profound shock. She received 500 cubic centimeters of blood in the right radial artery in 20 minutes with a rapid return of perceptible pulse and blood pressure which became stabilized at 100/65. She survived the operative procedure, but died 2 days later of a secondary rupture of the aneurysm.

CASE 5. A 55 year old male, known to have active pulmonary tuberculosis, was admitted to the hospital with intestinal obstruction of several days' duration. He developed increasingly profound shock with a blood pressure of 40/0. During the administration of 1500 cubic centimeters of whole blood via the left radial artery he showed all of the clinical responses to an intra-arterial transfusion in that his blood pressure became perceptible and his pulse and respiratory rate decreased. Skin temperature readings taken on the toes showed a rise of 5 to 10 degrees F.

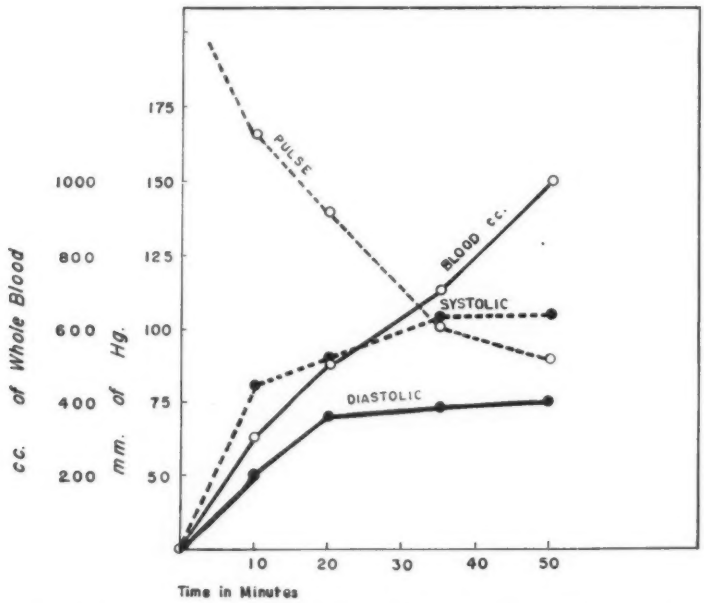

Fig. 6. Case 6. Graph showing relation of quantity of blood transfused to rise in blood pressure and fall in pulse rate, plotted on a time scale. Intra-arterial transfusion in placenta previa hemorrhage.

However, this patient had irreversible changes due not only to prolonged shock but also to pulmonary disease and long-standing intestinal obstruction. After completion of the transfusion in 45 minutes, blood pressure and cardiac output were not maintained, and he died approximately half an hour after termination of the transfusion. Necropsy showed pneumonia and gangrenous bowel.

CASE 6. This 23 year old primipara with placenta previa developed uncontrollable bleeding. An emergency cesarean section was performed to terminate the pregnancy and control hemorrhage. Two 500 cubic centimeter intravenous transfusions were begun but the patient showed no response. She had lost about 3000 cubic centimeters of blood and was in profound shock. An intra-arterial transfusion was begun while the intravenous transfusions were still being given. The patient had responded well by the time 300 cubic centimeters of whole blood had been forced into the left radial artery. She received a total of 1000 cubic centimeters of blood intra-arterially in 50 minutes and survived. Figure 6 gives a graphic representation of the response to the intra-arterial transfusion as plotted on a time scale, showing the pulse rate, diastolic and systolic pressures and the volume of blood infused.

CASE 7. A 40 year old negro male underwent surgery for ligation of an aneurysm of the left subclavian artery. During the operative procedure the aneurysm ruptured with severe hemorrhage and an estimated loss of 2500 cubic centimeters of blood. Administration of two 500 cubic centimeter blood transfusions was begun intravenously. Within 10 minutes this patient did not have a perceptible pulse or blood pressure and developed gasping respirations. At this point 2000 cubic centimeters of whole blood were transfused into the right radial artery over a period of 40 minutes. There was a rapid rise in blood pressure which was maintained at 130/60 during the operation and after the procedure was completed.

CASE 8. A 36 year old negro female was admitted with a single gunshot wound of the abdomen. She was in shock upon admission, but responded well to intravenous saline and glucose and 1000 cubic centimeters of whole blood intravenously. In the operating room, when anesthesia was induced, the patient's blood pressure dropped suddenly to 70/40. Two intravenous transfusions were started, and after 25 minutes 600 cubic centimeters of blood had been administered. The blood pressure remained at 60/30, with rapid pulse and shallow respirations. An intra-arterial transfusion was begun in the right radial artery and within 15 minutes 500 cubic centimeters of blood had been given, with a rise in pressure to 90/60. In the next 25 minutes the patient received an additional 1000 cubic centimeters of blood and her blood pressure rose to 130/70. The patient sur-

vived the closure of two perforations of the small intestine, and maintained a blood pressure of 130/85 throughout the procedure.

CASE 9. A 46 year old male, diabetic, isopropyl alcohol addict was admitted for drainage of a right perinephritic abscess. In the course of 22 hospital days, 3 operations were performed under general anesthesia for incision and drainage because of persistent loculation. Five days after the third drainage, the patient suddenly began to bleed from the operative wound. There was an estimated blood loss of 2500 cubic centimeters, resulting in profound shock. Despite two 500 cubic centimeter intravenous transfusions given as rapidly as possible, the patient became moribund with gasping respirations and marked cyanosis. An intra-arterial transfusion was begun in the left radial artery, while the patient was prepared for a fourth exploration under light cyclopropane anesthesia. A total of 1,750 cubic centimeters of blood was given over a period of 30 minutes, the first 500 cubic centimeters in a period of 6 minutes. The patient rapidly improved, blood pressure stabilized at 100/60, the color became good, and respirations were deep. A nephrectomy was performed and recovery was uneventful.

CASE 10. A 53 year old negro male was admitted for esophagoscopy because of suspected esophageal stricture. Six years previously he had undergone subtotal gastrectomy for benign peptic ulcer with obstruction. While in the hospital he developed melena, which persisted for a month, with frequent blood losses of 500 to 750 cubic centimeters, and incipient shock. Roentgenograms demonstrated a partial obstruction of the stoma with spasm. Forty-three days after admission, exploration for control of the bleeding point was considered imperative. An exploratory laporotomy was performed under continuous spinal anesthesia. The left radial artery was cannulated and intermittent intra-arterial transfusions were given throughout the operative period. A total of 1500 cubic centimeters of blood was infused over the two hour period, and the blood pressure was stabilized at 100/60. Each time a trend toward a fall in pressure was noted, the rate of blood flow into the artery was increased. The patient withstood the procedure surprisingly well despite his critical condition. Surgery consisted of gastrotomy, control of bleeding points, and establishment of a second anterior gastroenterostomy. Recovery was uneventful except for postoperative intestinal obstruction 7 days later.

CASE 11. A nephrectomy was performed on a 50 year old woman for a large hypernephroma of the right kidney. The kidney and tumor together approximated the size of the patient's liver. Due to the technical difficulties involved in the removal of the mass, the patient was under anesthesia for 4 hours. Throughout the operation the patient had frequent extra systoles and manifested shock whenever the peritoneal contents were handled. In the course of the 4 hours the patient had received 1000 cubic centimeters of whole blood intravenously as well as 1000 cubic centimeters of normal saline. Toward the end of the fourth hour, the patient's blood pressure became imperceptible, the pulse rapid and irregular. An intra-arterial transfusion was started in the right radial artery, and 1000 cubic centimeters of blood administered within 40 minutes. The patient's blood pressure rose to 110/90 and her condition improved to the point where she was considered to be out of danger. The needle was removed from the radial artery; the artery was ligated and the wound closed. The patient did well for almost an hour, but at the end of this period showed progressive signs of impending shock. She was given 10 cubic centimeters of adrenal cortical extract (25 rat units) intravenously and cardiac stimulants without effect. During this interval, a 500 cubic centimeter intravenous transfusion was given. At the end of the hour the patient's blood pressure was again imperceptible and the pulse thready. A second intra-arterial transfusion was begun in the left posterior tibial artery. In the next hour the patient received 1500 cubic centimeters of blood intra-arterially at a mean pressure of 120 millimeters of mercury. An additional 10 cubic centimeters of adrenal cortical extract and 0.25 milligram of ouabain were injected intra-arterially during the course of transfusion. When the transfusion was completed the patient's blood pressure was 100/75, pulse strong but irregular, respirations 20 per minute, color good and extremities warm. The patient survived and excreted 800 cubic centimeters of concentrated urine from her remaining kidney during the first 24 hours.

CASE 12. Transurethral prostatectomy for vesical neck obstruction was performed on a 60 year old male. During the course of the procedure, arterial bleeding was troublesome and required frequent and extensive coagulation. Within the first 24 hours there was only minimal bleeding. However, on the second postoperative day the patient began to pass large amounts of blood through the indwelling catheter, with a resulting fall in blood pressure from 140/90 to 60/30, in spite of almost continuous intravenous transfusion. Approximately 60 hours after operation he underwent suprapubic cystotomy for control of the hemorrhage. Blood loss prior to cystotomy was estimated to be 3000 cubic centimeters, with an additional loss of 4000 cubic centimeters during the procedure. He had received 6500 cubic centimeters of blood intravenously, a portion of this rapidly, using pressure technique. One hour and twenty minutes after cystotomy was begun, his blood pressure became imperceptible and his pulse rate 90 but thready. An intra-arterial transfusion was started in the right radial artery and 500 cubic centimeters of blood administered at 120 millimeters of mercury in 12 minutes. The blood pressure in the opposite arm was recorded as 90/60. In the course of the next 40 minutes an additional transfusion of 1000 cubic centimeters of blood was given intra-arterially, resulting in a stabilized pressure of 110/60. The hemorrhage was partially controlled and operation completed. Postoperatively the patient's blood

pressure remained around 110/60 for 5 hours, during which time no further transfusions were given. At this point a profuse hemorrhage occurred in the operative wound, and the patient expired before additional blood could be given.

DISCUSSION

The clinical results of intra-arterial transfusion have closely paralleled the observations made upon laboratory animals. The pressure responses, the volume of blood needed for response, and the survival criteria are identical as shown in the case histories and in Table II.

The results of our experimental and clinical use of blood transfusion by the intra-arterial route have substantiated the premise upon which the earlier investigators worked; that is, an immediate and sustained response is effected, with rapid rise in blood pressure and restoration of blood volume. A similar result may be secured experimentally with administration of blood intravenously under pressure; however, the time required for administration and response is considerably longer and the danger of cardiac embarrassment ever present.

With the clinical experience to date, intra-arterial transfusion should find a definite place in the treatment of shock. There are, however, well-defined limitations for its use.

Indications. Administration of blood by this method is indicated primarily in the treatment of shock resulting from a rapid decrease in blood volume, severe traumatic shock which fails to respond adequately to conventional therapy, exsanguination in obstetric emergencies, intra-abdominal and intra-thoracic hemorrhage. Anesthetic emergencies and asphyxia may also respond to intra-arterial transfusion. It is recommended that other measures to combat shock or hemorrhage, such as the administration of stimulants, oxygen, intravenous infusion and transfusion, be used simultaneously.

Contraindications. Intra-arterial transfusion involves the sacrifice of an artery, and is a procedure which should be reserved for extreme emergencies after conventional methods of therapy have failed to effect a satisfactory response.

This procedure does not lend itself to the treatment of the terminal stages of acute or chronic disease in which a response might be only transitory, as demonstrated in Cases 1 and 5 (Table II) in which the patients died after an initial response to the transfusion. The widsom of an intra-arterial transfusion in the presence of heart disease or heart failure is debatable.

Active bleeding from a wound, peptic ulcer or traumatized organ is not in itself a contraindication for intra-arterial transfusion, provided there is a possibility of control of the hemorrhage. It is obvious, however, that with this, as with any other procedure for replacement of blood, continued or recurrent hemorrhage will vitiate whatever improvement has occurred, as seen in Case 12.

SUMMARY

A method for the rapid administration of blood intra-arterially is presented with experimental observations and report of its clinical application in 12 patients. This procedure can be lifesaving in cases of extreme emergency where the outcome may otherwise be fatal because of hemorrhage and shock.

REFERENCES

1. Birillo, I. A. Khirurgiya, 1939, 8: 1-60.
2. Davis, H. A., Jermstad, R. J., and Choisser, R. M. Proc. Soc. Exp. Biol., N. Y., 1937, 37: 144-146.
3. Eckstein, R. W., Liebow, I. M., and Wiggers, C. J. Am. J. Physiol., 1946, 147: 685-694.
4. Gardner, W. J. Personal communication.
5. Glasser, O., and Page, I. H. Cleveland Clin. Q., 1946, 13: 125-127.
6. Kay, E. B., and Hacker, V. D. J. Am. M. Ass., 1947, 134: 604-605.
7. Kendrick, D. B., Jr., and Wakim, K. G. Proc. Soc. Exp. Biol., N. Y., 1939, 40: 114-116.
8. Kohlstaedt, K. G., and Page, I. H. Arch. Surg., 1943, 47: 178-191.
9. Shaffer, J. O. Surgery, 1947, 21: 659-661.
10. Wiggers, C. J. Exp. Med. Surg., 1943, 1: 2-14.

URINARY TRACT CHANGES IN CERVICAL CARCINOMA

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IN 1858 Wagner reported the presence of marked ureteral dilatation in one-third of women who died of cervical carcinoma. This paper provided the stimulus for further investigation into the problem of the changes in the urinary tract which result from cervical malignancy. In the early reports most conclusions were arrived at from autopsy material. This was to be expected, for pyelography had as yet not been developed, and surgical technique had not progressed sufficiently to afford the surgeon time to make a careful inspection of the urinary system at the time of the operation.

Williams in 1895 presented in the *British Gynecological Journal* his findings in the autopsies of 78 women who died of advanced cervical cancer. In every case there was evidence of renal disease. In 67 per cent he noted the presence of a gross hydronephrosis and hydroureter. Three-quarters of all patients had demonstrable parametrial involvement by carcinoma. Ewing later concluded from an exhaustive study of the problem that "the natural termination of most cases of uterine cancer is through uremia by occlusion of the ureters." Graves and Kickham (6) substantiated this statement by Ewing in a study of 600 autopsies. These authors found evidence of ureteral obstruction in 75 per cent of the material examined. This occlusion of the ureter was brought about by the constricting effect of edema and inflammation, and by the direct invasion of the ureteral wall by tumor cells. The same authors (7) in a second similar investigation concluded that 78 per cent of patients with broad ligament involvement from cervical cancer had some demonstrable degree of ureteral occlusion.

During the last 15 years, as a result of the ever increasing use of radium and x-ray in the treatment of carcinoma of the cervix, the etiology of the changes noted in the urinary tract has become a subject of much debate. Several authorities have suggested that the radiation therapy plays a role in the production of scarring and fibrosis of the juxtavesical portion of the ureter, which, because of its proximity to the cervix, is most vulnerable to the effects of the ray. They are of the opinion that it is this scarring and fibrosis which are responsible for the ureteral narrowing which is noted following therapy. These are the conclusions of Herger and Schreiner, Bugbee, and others who definitely place the major blame for the development of the hydronephrosis and hydroureter on therapy rather than on the underlying disease. Everett (3) in 1934 reported the changes in 18 patients; 11 of whom developed dense ureteral strictures as a result of radiation therapy or carcinoma of the cervix. In the same paper he cited 2 cases of ureteral stricture which followed radiation for benign conditions. Again in 1939 Everett (4), in an article on the effect of carcinoma on the urinary tract, concluded that approximately 50 per cent of the patients treated with x-ray and radium for cervical malignancy showed evidence of some constricting lesion involving the lower portion of the ureter.

In reviewing the records of the oncological patients at the University of Maryland, we too noted the high incidence of urinary tract disease associated with cervical cancer. From this survey we were unable accurately to determine whether the parametrial spread of the carcinoma, or the effects of the radiation were responsible for the urinary tract changes which developed. It was necessary, therefore, to investigate a series of patients with the several grades of cervical cancer, and to determine exactly the status of the urinary tract before and after radiation therapy. We felt that only through such a plan could the emphasis be placed on the responsible agent. Thirty-seven patients compose this present series, repre-

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Fig. 1. Grade 1. Hydronephrosis before treatment was begun.

Fig. 2. Grade 1. Hydronephrosis and hydroureter before treatment.

senting consecutive admissions of new patients with cervical carcinoma to the oncological division of the gynecological department. All patients were treated according to the same plan, and all patients have been followed for at least 5 years.

Of the 37 patients comprising this series, 31 (84%) were white and 6 (16%) were colored. The youngest was a 25 year old negress with a grade 1 carcinoma, the oldest, a 75 year old white woman with an advanced clinical grade 3 cervical lesion. The average age of the group was 50 years. All patients were married and all but 2 had completed one or more pregnancies. The greatest number of children was 11, and the overall average for the group was 4.

In 11 patients of the group (29%) the carcinoma was confined to the portio of the cervix. Nine patients (24%) had spread of the disease process to the vaginal vaults. The remaining 17 patients (47%) showed unquestionable parametrial involvement and were therefore classified clinically as grade 3. These statistics suggest that the series, although it was small, represented an average cross section of carcinoma of the cervix.

A detailed history and complete general and special physical examinations were done on the first visit. The carcinoma was graded clinically according to Schmitz. A biopsy of the cervix was taken, and a 24 hour report of the tumor made. The microscopic classification used was that of Ewing. The majority of patients in the series received radium therapy before deep x-ray. There were only 3 exceptions to this general rule.

We are of the opinion that the technique of radium implantation is a most important factor. For that reason a detailed description of our method is vital to the problem under discussion. Radium implantation at the University of Maryland is an operating room procedure and is generally carried out under sodium pentothal anesthesia. Proctoscopic examina-

tion is done first to rule out the presence of rectal involvement. Following a routine pelvic clean-up, the patient is carefully examined to determine the pelvic status more accurately. It is this examination under anesthesia that is used in the final clinical grading of the lesion. Thirty milligrams of radium with a 2 millimeter lead equivalent filter are placed, in tandem, in a flexible rubber sac. This is inserted into the cervical canal. An adhesive tape aluminum foil plaque is made to conform to the size and the shape of the cervical growth. This plaque contains 70 milligrams of radium with a 3 millimeter lead equivalent filter. The tubes of radium are equally spaced by small felt blocks. By this method the distribution of the radiation is entirely uniform. The plaque is introduced in such a manner as to focus the greatest concentration of the ray against the tumor. The bladder and the rectum are protected from radiation by the heavy filters at the extremities of each tube. The plaque is held in place by a large vaginal pack. The pack is inserted meticulously in order to cause the maximum of distention of the vagina. This displaces the cervix and the source of the radiation as far as possible from the bladder and the lower portions of the ureters. The radium is left in place for 30 hours, so that a total of 3,000 milligram hours of radiation is given. The same technique is used 3 weeks later to give the second radium treatment. Each patient thereby receives a total of 6,000 milligram hours of radiation. This portion of the therapy is followed in 3 weeks by a course of deep x-ray, totaling 6,000 to 8,000 roentgen units. All deep x-ray is given in divided daily doses through the four standard portals. A second cycle of deep x-ray therapy is routinely given 12 weeks later. Throughout all therapy and at regular intervals thereafter all patients are followed by the oncologists.

Before the initiation of any therapy all patients in the series had a complete urological study. This consisted of water cystoscopy at which time a careful inspection of the urethra and bladder were made for evidence of metastatic malignancy, or for the typical cobblestone effect of pressure from an extravesical growth. The ureters were then catheterized with No.6 x-ray catheters and complete bacteriological studies made of the entire urinary system. A flat film of the abdomen and a retrograde pyelogram were made by the use of 15 per cent skiodan in gum acacia. The pyelogram was made by the gravity method on the side which showed the parametrial involvement, or, if none was present, on the right side. The contour of the ureter and kidney pelvis was carefully studied, and the transverse diameter of the ureter measured at four locations. These measurements were made uniformly at the level of the ischial spine, the lower junction of the ilium and the sacrum, and at the level of the transverse process of the third and fourth lumbar vertebrae. This same urological study was repeated on each patient 1 year after the completion of all therapy, and the two constitute the basis of this report.

Fig. 3. Grade 2. Hydronephrosis and slight hydroureter before treatment.

Twenty patients (54%) of the group gave some initial positive urological history; 15 complained of nocturia, 4 of dysuria, and 1 of questionable hematuria. No patient complained of urinary symptoms following the first radi-

Fig. 4. Grade 3. Hydronephrosis before treatment was begun.

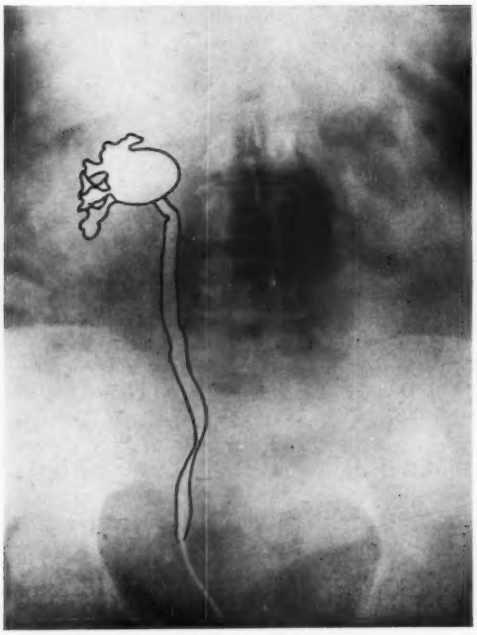

Fig. 5. Grade 3. Hydronephrosis and hydroureter before treatment.

um treatment, and only 4 had mild dysuria and frequency as a result of the second. These symptoms were transitory and required only a minimum of medication. Five patients had urological complaints following deep x-ray therapy, and as before, all symptomatology was temporary and none suggested bladder disease.

On cystoscopic examination prior to the initiation of therapy, 7 patients (18%) had some degree of demonstrable bladder pathology. Two patients showed a mild cystitis. This apparently was in no way associated with the cervical malignancy. In 3 patients there was evidence of elevation of the bladder floor with the cobblestone effect previously mentioned. All 3 patients had advanced cervical cancer with definite parametrial spread of the disease. The remaining 2 patients showed evidence of early metastatic cancer, also associated with a far advanced cervical lesion.

By comparison at the repeat cystoscopic study 1 year later only 2 patients (0.5%) had bladder pathology. In one patient previously suspected of having metastatic carcinoma the lesion was now quite obvious, and a positive biopsy was obtained. The other patient had developed elevation of the bladder floor. Six patients who originally had some demonstrable bladder lesion showed no evidence of it on the repeat study at the end of the year.

The presentation of a statistical review is at best difficult, and at times can be both confusing and boring to the reader. Fortunately this group is small and the points to be discussed are limited to the three major grades of cervical malignancy and the presence or absence of urinary tract pathology.

Of the entire group of 37 patients, 10 (27%) showed some degree of urinary tract dilatation before treatment was instituted. This varied in severity from a very slight hydronephrosis in a patient with an early carcinoma, to an unquestionable hydronephrosis and hydroureter found in 1 of the patients with a grade 3 malignancy. This overall incidence of urinary

Fig. 6. Grade 1. Hydronephrosis and hydroureter. No change after treatment. Compare with Figure 2.

Fig. 7. Grade 1. Hydronephrosis and hydroureter after treatment. Compare with Figure 1.

tract dilatation is about as would be expected from such a group.

In the series there were 11 patients in whom the cancer was confined to the portio. In 2 of this group (18%) urinary tract dilatation was found. In one patient this was very slight in degree and was limited to the renal pelvis (Fig. 1). The second patient showed evidence of a moderate dilatation of both the renal pelvis and the ureter (Fig. 2). Of the 9 patients with a grade 2 carcinoma, only 1 showed the presence of demonstrable urinary tract dilatation. This was more marked in the renal pelvis, but there was some slight degree of hydroureter associated with it (Fig. 3). On examination before treatment, 7 patients (41%) of the 17 with advanced carcinoma and definite parametrial extension showed varying degrees of hydronephrosis and hydroureter. In 3 these changes were confined to the kidney pelvis (Fig. 4). The remaining 4 patients showed evidence of both a hydronephrosis and hydroureter (Fig. 5).

These findings substantiate the belief that the advanced carcinomas with definite parametrial spread are most prone to be associated with urinary tract dilatations.

One year following the completion of all therapy, each patient was again completely studied, and the same urological determinations were done. A meticulous comparison was made of the retrograde pyelograms, and the difference carefully noted.

Originally, before therapy had been instituted, 2 patients with grade 1 carcinoma had shown dilatation of the urinary tract. The patient in whom a moderate hydronephrosis and hydroureter had been found exhibited no change at the time of the repeat urological study (Fig. 6). This patient is living and well more than 7 years after therapy, and has continued free of urinary symptoms. The patient who had shown evidence of a slight dilatation confined to the renal pelvis, proved on repeat examination to have a dilatation of both the kidney pelvis and the ureter (Fig. 7). Asso-

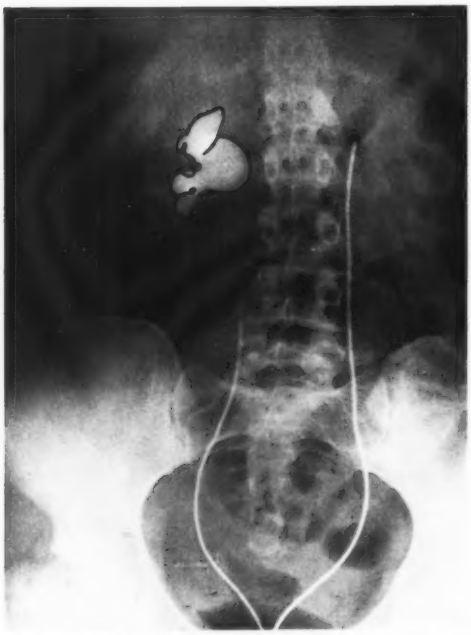

Fig. 8. Grade 2. Hydronephrosis and slight hydroureter. Slight increase after treatment. Compare with Figure 3.

ciated with this change there was a marked extension of the original carcinoma. Two years later the patient died either of tuberculosis or pulmonary metastasis. Unfortunately no autopsy could be obtained. It is of great significance that no patient with a carcinoma grade 1 developed a dilatation of the urinary tract between examinations.

In the group of patients with grade 2 carcinoma of the cervix, one had demonstrable urinary tract changes before therapy. Repeat examination revealed only a slight increase in the degree of dilatation (Fig. 8). Shortly thereafter the patient developed definite pelvic metastasis, for which a third cycle of deep x-ray therapy was given. The patient has remained in *status quo*, is living, and is free of urological symptoms. Again it is of significance that no patient with a grade 2 carcinoma developed demonstrable urinary tract changes during the time between examinations.

Of the 17 patients with advanced grade 3 carcinoma, 7 originally had urinary tract dilatation. Six of these showed no appreciable change in the time between examinations (Figs. 9 a and b). Four of the group are living and well, and all are survivals of 5 years or more. Two patients of the original 7 died, one of advanced carcinoma, the other of a cerebral accident. One patient with a grade 3 carcinoma had an increase in the degree of dilatation of the urinary tract. This change was confined to the kidney pelvis, and no increase in the diameter of the ureter could be demonstrated. In spite of therapy there was a definite spread of the malignant process, and the patient died 2 years later of carcinomatosis.

In contrast to the patients with grades 1 and 2 carcinoma, none of whom developed urinary tract dilatation, there were 4 with advanced grade 3 malignancy who at the end of the year exhibited changes which had not been present previously. Two of the 4 patients had definite hydroureter and hydronephrosis (Figs. 10 a and b). These patients have subsequently died in uremic convulsions. In the third patient the dilatation of the pelvis of the kidney was obvious, but there was question as to any change in the size of the ureter. This patient died of carcinomatosis. The fourth patient to develop urinary tract pathology in the time between examinations revealed only a moderate dilatation confined to the kidney pelvis. This patient has remained well and free of all symptoms for more than 5 years.

In retrospect, we had found that before the initiation of any therapy, 27 per cent of the entire group had shown some degree of urinary tract dilatation. Seventy-five per cent of those who did show these changes had demonstrable parametrial extension of the disease. By comparison at the end of the survey period 38 per cent of the patients showed some degree of hydronephrosis or hydroureter. At this time 79 per cent of those having dilatations also had extension of the malignancy.

We were impressed by the consistency with which we found the association of urinary tract dilatations and extension of the cervical cancer into the parametrial tissues. A second fact was apparent from this survey; and one which we felt must be taken into consideration in the final analysis. Patients who had grade 3 carcinoma of the cervix were the only ones to de-

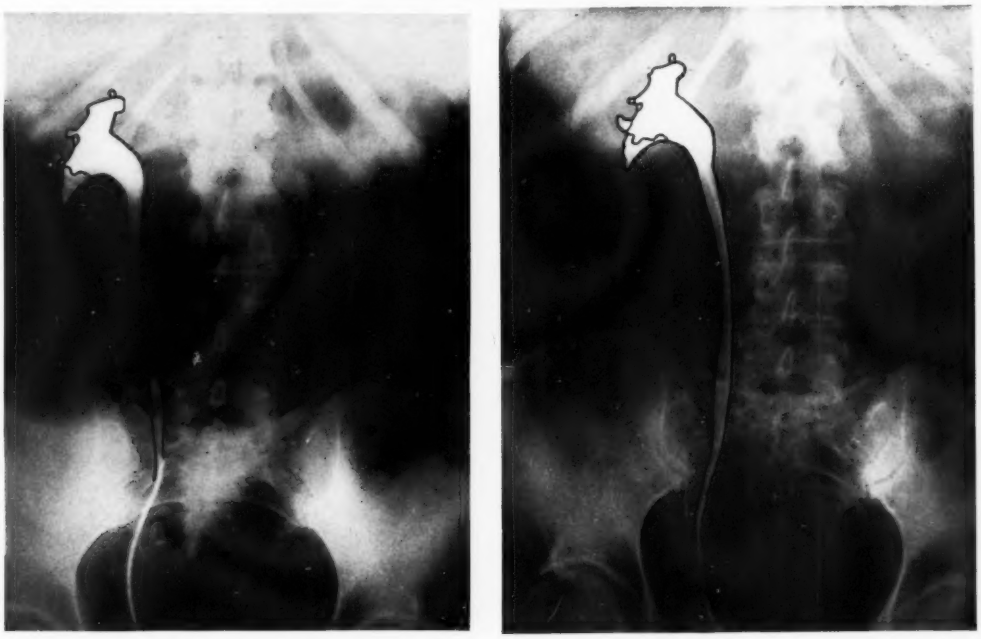

Fig. 9. a, left, Grade 3. Hydronephrosis and slight hydroureter before treatment. b, No change after treatment. Compare with a.

velop urinary tract dilatations during the time between examinations. And furthermore, all patients who exhibited an increase in the hydronephrosis and hydroureter showed a definite spread of the disease in spite of therapy, and subsequently died of the malignancy (Table I).

It has been established that scarring and fibrosis are the end-results of radiation. This is true of normal and malignant tissue. If the ureter in its course through the pelvis were to receive sufficient radiation to bring about scarring and fibrosis, then eventually a stricture would develop at that point of the ureter. This stricture in time would produce dilatation of the upper urinary tract. This is the basis of Everett's (4) belief; he had maintained that in time half of the patients treated by irradiation for cervical cancer will develop some degree of ureteral stricture.

The effect of radiation is directly proportioned to the dose and time, and inversely proportioned to the distance from the source of the ray. Obviously, therefore, if we were to eliminate stricture effect from radiation as a cause of the urinary tract changes, we had to determine the exact course of the ureter through the pelvis. In addition we had to estimate the exact amount of radiation delivered to all points on the ureter by our particular technique of therapy. Finally we had to know the minimal dose of radiation required to bring about these stenosing effects.

The anatomic position of the pelvic ureter is not constant. The course of the right and left ureter differs quite markedly as a result of the presence of the sigmoid and rectum. However, the pars intermedia of the pelvic ureter, that portion within Mackenrodt's ligament, is similar on either side. It is through this area that the ureter lies closest to the cervix where for a short distance it is from 1.5 to 2.5 centimeters lateral to the cervix (1). However, this distance is altered greatly by the position of the vessels, mostly veins, which surround the ureter on all sides. As the veins from the lower

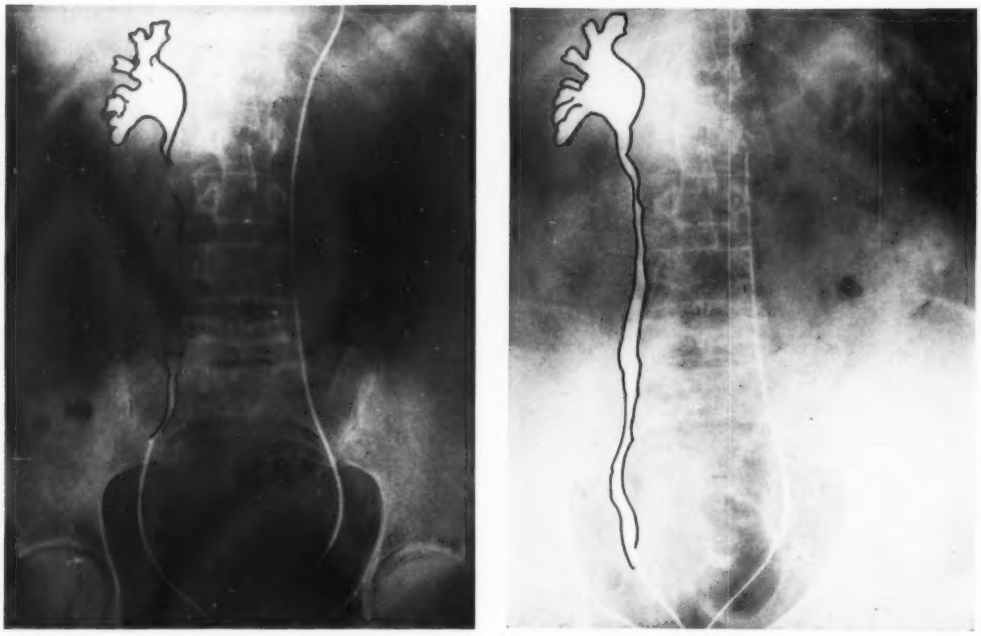

Fig. 10. a, left, Grade 3. Normal before treatment. b, Hydronephrosis and hydroureter after treatment Compare with a.

uterus and upper vagina anastomose they lie medially and tend to displace the ureter laterally toward the pelvic wall. On its exit from Mackenrodt's ligament, the ureter diverges rapidly and enters the bladder obliquely about 1.5 centimeters below the level of the anterior cervical lip. Most important of all is the fact that the ureter in its course through these areas is held firmly in place by the surrounding vessels and the connective tissue framework.

Upward traction on the uterus increases the distance between the cervix and the ureters, a great asset in doing a total hysterectomy from above. If this were not true, injury to the ureter as it transverses the ligament of Mackenrodt would be a much more common occurrence. In radiation work the maximum accurate packing of the vagina accomplishes this same effect, namely, to push the uterus and cervix upward and backward away from the ureters fixed in their beds. On this we believe depends the successful protection of the ureters from the effects of radiation.

To determine accurately the change of distance before and after vaginal packing we have made measurements on operative and autopsy material and on normal patients in the cystoscopic clinic. In the latter group we first passed x-ray catheters into the right and left ureters. Using radium filters we made a plaque similar in size to one used in therapeutic application. This was placed against the cervix and a flat film of the abdomen was taken (Fig. 11). The vagina was then carefully packed in the routine manner and a second roentgenogram was taken (Fig. 12). Measurements were made of the change in distance between the ureters and the cervical plaque before and after packing. In the average case we were able to push the uterus and cervix upward and backward toward the promontory of the sacrum so that the distance of the source of radiation from the most vulnerable portion of the ureter was increased by about 5.5 centimeters. In patients obtaining the most effective packing, this increase was as much as 8.5 centimeters.

Having determined the relative position of the ureters to the source of the ray, we next had to learn the amount of radiation delivered to the various portions of the pelvic ureter by our particular method of radium implantation. For this we turned to the work of A. N. Arneson, who, among others, had estimated the distribution of radiation within the average female pelvis. His measurements for the size of the bony pelvis and the viscera were taken from the work of Davis and Williams. Following his technique we plotted the isodose curves of radiation delivered within the pelvis by our method of therapy. Superimposing on these curves the various positions of the ureters as determined by our cystoscopic studies, the authors have been able to estimate the dosage of radiation to all portions of the pelvic ureter. From this study we have concluded that at no point in its course through the average pelvis is the ureter subjected to more than 35 to 45 milligram hours of exposure. In those patients in whom the maximum effectiveness of the vaginal packing was obtained, the dosage was appreciably less. These patients received as little as 18 to 25 milligram hours of radiation.

Fig. 11. Radium filters before vaginal packing.

TABLE I

Clinic No.	Carcinoma grade	Urographic diagnosis		Clinical change after 1 year	Present status
		Before therapy	After 1 year		
Z-9622	1	Hydronephrosis	Hydronephrosis and hydroureter	Parametrial extension	Died. Pul. metastasis
Z-7087	1	Hydronephrosis and hydroureter	No change	No extension	Living and well
BB-9120	2	Hydronephrosis, early hydroureter	Very slight increase	Parametrial extension	Fair
DD-3760	3	Hydronephrosis	No change	No extension	Living and well
BB-4656	3	Hydronephrosis	No change	No extension	Living and well
CC-8195	3	Hydronephrosis and hydroureter	No change	Parametrial extension	Died. Carcinomatosis
DD-4714	3	Hydronephrosis and hydroureter	No change	No extension	Died. Cerebral accident
Z-9036	3	Hydronephrosis and hydroureter	No change	No extension	Living and well
CC-3329	3	Hydronephrosis and hydroureter	No change	No extension	Living and well
Z-3530	3	Hydronephrosis	Slight increase	Marked extension	Died. Carcinomatosis
DD-2817	3	Normal	Very early hydronephrosis and hydroureter	Marked extension	Died. Uremia
DD-1903	3	Normal	Early hydronephrosis and hydroureter	Marked extension	Died. Carcinomatosis
BB-4096	3	Normal	Early hydronephrosis	Marked extension	Died. Carcinomatosis
CC-6799	3	Normal	Very early hydronephrosis	Questionable extension	Living and well

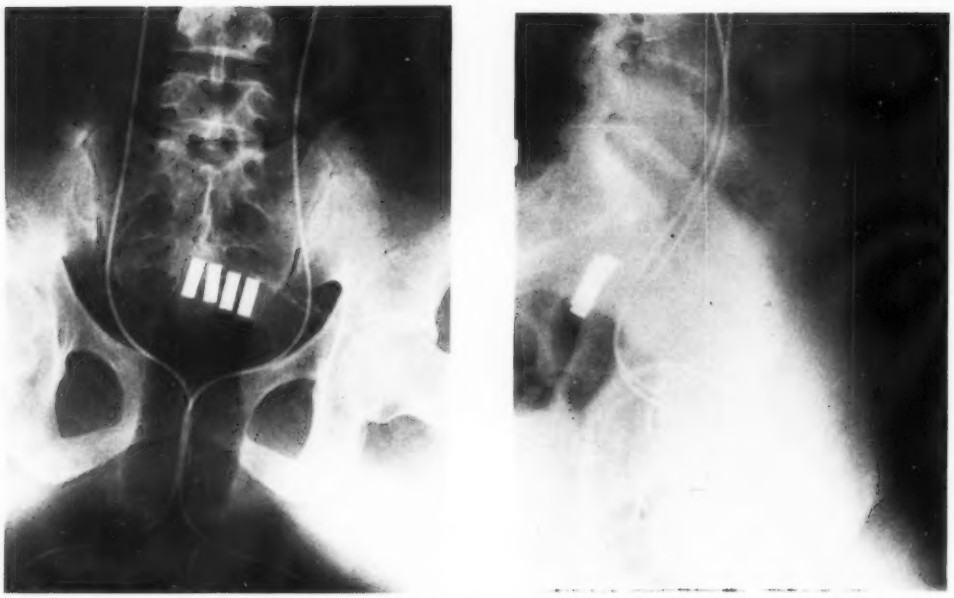

Fig. 12. a, left, Radium filters, after packing. b, Radium filters, after packing. Lateral view.

From these studies we had been able to determine, with some degree of accuracy, the amount of radiation given to the most vulnerable portion of the ureter. Knowing this dosage we had only to compare it with the amount of exposure needed to cause stenosis of the ureter.

The majority of this work has been carried out in laboratory animals. Martin and Rogers in their work on dogs found that 100 milligram hours of radiation to the abdominal portion of the ureter resulted in a complete stenosis. By back pressure this subsequently caused a hydronephrosis and hydroureter. Doses of less than 50 milligram hours of radiation produced very little if any effect. Demonstrable changes were not noted until after the ureter had been exposed to 75 or more milligram hours of radiation.

A correlation of these studies leads to the conclusion that even with inadequate vaginal packing our method of cervical radiation definitely delivers less than the minimal amount necessary to produce stenosis of the ureter.

These results are in keeping with our clinical studies in which we found that in patients without extension of the cervical carcinoma into the parametrial tissue, a stenosis of the ureter did not develop during the time between the two urological studies. Objection might well be raised on the basis that the 1 year period of time was not sufficient to produce the stenosis necessary for the eventual development of a hydronephrosis or hydroureter. We can best answer this objection by saying again that by our particular method of radium implantation and vaginal packing, as previously described, even the most vulnerable portion of the ureter receives considerably less than the minimal amount of radiation necessary to cause stenosis.

CONCLUSIONS

From these studies we have arrived at the following conclusions:

1. The more advanced the original cervical carcinoma, the more frequent is the association of urinary tract dilatation before the initiation of radiation therapy.

2. The development of a hydronephrosis and hydroureter during or after treatment has in every case been associated with advancing

malignancy, and has invariably proved to be a grave prognostic sign.

3. The majority of patients with carcinoma grades 1 and 2 did not show changes in the urinary tract before therapy, and none of the patients in these groups developed a dilatation during the period of time between examinations.

4. Urological studies of all patients who have cervical carcinoma are indispensable for purposes of intelligent evaluation and management.

5. Radiation therapy will not cause stricture of the ureter, if the dosage is not excessive and provided the source of the ray is displaced from the ureter by accurate maximal vaginal packing.

REFERENCES

1. ARNESON, A. N. Radiology, 1936, 27: 1.
2. BUGBEE, H. G. J. Mount Sinai Hosp., N. York, 1938, 4: 712.
3. EVERETT, H. S. Am. J. Obst., 1934, 28: 1.
4. Ibid., 1939, 38: 889.
5. EWING, JAMES. Neoplastic Diseases. 3rd ed., p. 602. Philadelphia: W. B. Saunders Co., 1919.
6. GRAVES, R. C., and KICKHAM, C. J. E. Surg. Gyn. Obst., 1936, 63: 785.
7. Idem. J. Urol., Balt., 1936, 36: 618.
8. HERGER, C. C., and SCHREINER, B. F. Surg. Gyn. Obst., 1926, 43: 740.
9. MARTIN, C. L., and ROGERS, E. T. Am. J. Roentg., 1926, 16: 215.
10. PEHAM, H. V., and AMREICH, J. Operative Gynecology. Vol. 1. Philadelphia: J. B. Lippincott Co., 1934.
11. WAGNER. Der Gebaermutterkrebs; eine pathologisch-anatomisch Monographie. Leipzig: B. G. Teubner, 1858, 6: 169.
12. WILLIAMS, R. Brit. Gyn. J., 1895, 11: 529.

A METHOD OF REPAIR FOR A COMMON TYPE OF TRAUMATIC INCONTINENCE OF THE ANAL SPHINCTER

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AMONG the traumatic causes of incontinence of the anal sphincter are accidental injuries, obstetrical injuries, operations in the anorectal region, and forcible dilatation of the anorectal sphincteric apparatus. The majority of cases of fecal incontinence occur after anorectal fistulectomy and are usually due to improper or too extensive incision of the anorectal ring or to the pernicious practice of postoperative packing. However, a considerable number follow simple incision of an abscess or an otherwise uncomplicated hemorrhoidectomy. The greatest number of defects occur in the lateral quadrants although, contrary to common belief, in many instances the defect is directly posterior.

The term "sphincter mechanism" is used advisedly to indicate a more complex structure and action than are comprised by merely the internal and external sphincters commonly mentioned when the anorectal ring is referred to. A clear conception of the anatomic components of the anorectal ring is essential for the surgeon undertaking operative procedures in this region or attempting repair of the already injured muscle.

The extent of injury leading to incontinence may vary from a segmental one to complete destruction or absence of the muscle. The method of repair to be described here deals only with those in which a relatively small segment is lost, although it may be modified to apply to larger defects.

Two factors are involved in the mechanism of incontinence. (1) Because of an actual increase in the circumference of the anus, the muscle, when it contracts, is unable to close the orifice. The interposition of a noncontractile and fixed scar abets the failure of complete closure. (2) Scar tissue in the muscle creates a sulcus interrupting the normal contour of the anal periphery. Because of the "puckering" action of the ovoid-shaped elements of the sphincters, the anus is normally corrugated, with elevations and depressions alternating about its circumference. When a portion of the muscle is replaced by a scar, the epithelium covering it forms a smooth trough through which there is an escape of feces and secretion. This sulcus, if not removed, may also be the source of contamination of an operative wound external to it.

Many types of repair of the incontinent sphincter have been offered, some of which appear to have met with a gratifying degree of success. Many failures are reported, however, with most of the methods employed. The so-called "classical repair" is probably the most widely used, although the literature is not fruitful in reports of its success and the concensus of those who have employed it is not wholly favorable. This method consists in dissecting out the scar tissue and reapposing the retracted muscle ends. Buie has found that, in those instances in which packing after fistulectomy has resulted in a wide scar separating the muscle ends, simple excision of the cicatrix is sufficient to correct the defect. The muscle need not be reapposed by suture. Blaisdell has developed an ingenious method in which, through an anterior incision, the muscle is reefed in such a manner that the circumference of the sphincters is decreased. Other procedures are based upon reflection of a section of the anococcygeal portion of the superficial fasciculus of the external sphincter ani muscle. For large defects fascial strips which encircle the canal and are sutured to the edges of the gluteal muscles have been described by Wreden, Stone, and McLanahan. The scarred muscle ends may be apposed through a semilunar incision concentric with the anus. This method, described by Blaisdell, has the distinct advantages of simplicity and of suturing through a scar with high tissue tension. Annular pursestring sutures have been used as

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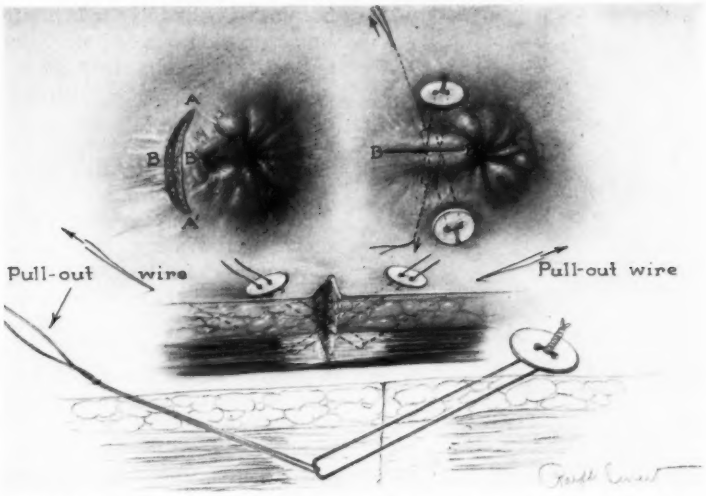

Fig. 1. Drawing of the steps in repair of a defect in the anal sphincter. Upper left, Note the location of the incision and the sulcus in the scar at the site of the defect. Upper right, The steel sutures have been laid and drawn up. The "pull-out" sutures are indicated by arrows. Note how the concentric incision has become radial and the present position of points *B* and *B'*. The sulcus has disappeared and is replaced by an invaginating elevation. The lower drawings are detailed cross sections to clarify the method of placing the retention sutures. Note that they are in scar tissue and that the two ends of each "pull-out" suture emerge through a single opening in the skin. Gauze should be placed between the buttons and the skin to prevent erosion.

retention sutures. Smiley has reported good results from the use of steel alloy wire as retention suture material in sphincter repair as has Kallett, who also used this method.

Some of the reasons for failure in attempted sphincter repair are the following: (1) There is a high incidence of wound infection with subsequent dehiscence of the wound. This location is obviously of high potentiality for contamination from the nearby fecal outlet. (2) When large retention sutures are used, particularly when placed so that strangulation of tissue occurs, a necrotic nidus of infection is formed. Retention sutures that have been described previously are almost inevitably strangulating. (3) Catgut absorbability is rapid in the presence of infection. When it is used as suture material, its holding strength is lost before the opposed structures are able to maintain union and separation occurs. (4) The sulcus in the scar between the divided muscle ends, as mentioned previously, remains after some types of repair. This results in contamination of the close-by operative wound during the immediate postoperative period of healing as well as in continued leakage or partial incontinence. (5) In the "classical repair," sutures are placed in poorly holding muscle and may not appose the dissected edges for a sufficient period of time for them to unite firmly. Further, the trauma imposed upon the muscle in the course of the operation results in further extension of cicatrization in the muscle.

The method to be described below is based upon Bunnell's principle of "suturing at a distance" with steel alloy wire, which he has evolved in the repair and reconstruction of tendons. It has other features which tend to overcome some of the factors in failure enumerated above. No. 34 steel alloy wire is employed. This has a diameter of 0.006 inch and is comparable in strength to a size in silk one-half diameter greater. It breaks at 7 pounds' tension. For greater strength, No. 30 or even No. 28 may be used. Its tensile strength is high; it ties smoothly and engenders a minimal tissue reaction. It should never be allowed to kink.

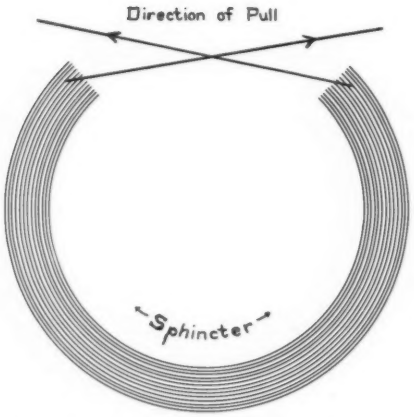

Fig. 2. Diagram to illustrate the direction of pull of the retention sutures.

The patient is prepared preoperatively with oral administration of nonabsorbable sulfa drugs, cleansing enemas, and a nonresidual diet. Transsacral anesthesia is preferable. The prone, jack-knife position is used. The anal canal is packed with an antiseptic-saturated gauze and carefully draped out of the operative field. Atraumatic, aseptic technique is observed. A crescentic incision, just lateral to, and centered over, the defect is made and carried down to the required level. Excessive scar is removed en bloc. The dissection is not carried back to normal muscle but rather the muscle ends are allowed to retain enough scar so that sutures may be firmly placed in scar tissue. It must be borne in mind at this point that the entire defect in the anorectal ring, which may include the levator ani, the longitudinal muscle of the rectum, the internal sphincter, and the two deeper bundles of the external sphincter, must be identified.

The steel wires are then laid as shown in Figure 1, being passed through the loop of the "pull-out" wire. Note in Figure 2 that the direction of pull is tangential to the circumference of the muscle, i.e. the end of the muscle to be apposed is held in direct line with its fellow which is, in turn, fixed in the same manner. The "pull-out" suture (illustrated in Fig. 1) is looped through the end of the holding suture and brought out through the skin with both of its ends threaded through the eye of a single needle. Thus, both ends of the "pull-out" suture emerge through a single opening in the skin. The steel sutures are then drawn up sufficiently to convert the longitudinal wound into a transverse one, and the defect is closed in layers without tension. The author prefers the use of fine, interrupted cotton sutures. The retention sutures are secured to the surface of the skin with buttons and tightened. Several layers of gauze are placed under the buttons to avoid pressure ischemia of the skin. When the operation is completed it will be observed that the longitudinal wound has been converted into a transverse one and that the sulcus referred to becomes a fold invaginating itself into the anus. Thus the normal corrugations of the anus are restored. No bowel movement is permitted for at least 7 days. The sutures are removed at end of 14 days.

This procedure has been employed upon three occasions with good results.

SUMMARY AND CONCLUSIONS

Failure often follows attempts at repair of the incontinent anal sphincter for a variety of reasons.

A method of repair is described which requires minimal dissection, converts the ditch-like defect into an elevation simulating the normal contour of the anus, obviates strangulating retention sutures, and provides sufficient suture traction in the proper direction.

REFERENCES

1. Blaisdell, Paul C. J. Am. M. Ass., 1939, 112: 614.
2. Idem. Surg. Gyn. Obst., 1940, 70: 692.
3. Ibid., 1942, 75: 634.
4. Buie, Louis A. Practical Proctology. Philadelphia: W. B. Saunders Co., 1938.
5. Bunnell, Sterling. Surgery of the Hand. Philadelphia: J. B. Lippincott Co., 1944.
6. Idem. J. Bone Surg., 1941, 23: 240.
7. Finochietto, R., and Esperne, P. Arch. argent. enferm. ap. digest., 1940, 15: 500. (Abstracted in Intern. Abstr. Surg., Surg. Gyn. Obst., 1941, 72: 152).
8. Kallett, H. I. Harper. Hosp. Bull., Detr., 1942, 1: 103.
9. Smiley, Kenneth E. Tr. Am. Proct. Soc., 1940: 191.
10. Stone, Harvey B. Arch. Surg., 1929, 18: 845.
11. Ibid., 1931, 97: 1205.
12. Ibid., 1932, 24: 120.
13. Stone, Harvey B., and McLanahan, Samuel. Ann. Surg., 1941, 114: 73.
14. Wreden, R. R. Arch. Surg., 1929, 18: 841.

TUBERCULOSIS OF THE CERVICAL LYMPH NODES

The Present Surgical Status

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TUBERCULOSIS of the cervical lymph nodes was a common disorder of childhood until about 1920 and its surgical treatment was firmly established. Dowd, who wrote extensively on the subject, reported nearly 700 personal cases in 1916. Shortly thereafter the incidence began to decrease so that Hanford, in 1933, could report on but 131 cases treated surgically. In England there was still a considerable number of cases and up to the time of the war the arguments for and against surgical treatment of tuberculous cervical lymphadenitis were published in the British literature by Thompson, Barrington-Ward, Turner, Franklan, Evans, and others.

Certain significant changes have taken place to alter the incidence of this disease since Dowd compiled his series of cases:

First, tuberculosis in dairy herds has almost been eliminated thus removing bovine tuberculosis as a factor. This is often mentioned but it was not a major consideration even in 1906 when Park examined a representative group of Dowd's cases and found that bovine tuberculosis accounted for only about 30 per cent of the cases.

Second, the widespread removal of tonsils and the replacement of the old guillotine operation by enucleation of the tonsils removed an important portal of entry not only for tuberculosis but also for pyogenic infections which lessen the resistance of the nodes to lymph-borne or hematogenous infection with tuberculosis. As the nodes draining the nasopharynx are usually the first involved this probably has some significance.

Third, the great decrease in tuberculosis generally has vastly diminished the chances for exposure. In 1915 a positive tuberculin test in a child over 2 years of age was not considered of great significance but in 1948 a positive tuberculin test at any time in childhood has considerable diagnostic weight. This is undoubtedly the most important factor in the decreased incidence of lymph node tuberculosis.

With so few cases encountered it is natural that the good surgical results of other years should be forgotten. Pediatricians (and many surgeons as well) are prone to consider the surgical treatment of accessible tuberculous lymphadenitis as ineffectual, dangerous, and disfiguring. For that reason every other form of treatment is tried first and the surgeon called only when a cold abscess is about to rupture. This concept is ridiculous. Surgical treatment, though differing from other neck dissections, can still produce the best results in properly selected cases, particularly if operation is performed before cutaneous sinuses have developed, and operation certainly need not be disfiguring.

Tuberculosis of the cervical lymph nodes may occur at any age but is predominately a disease of childhood. It is not frequently associated with active pulmonary tuberculosis and is present in only about 5 per cent of the patients admitted for tuberculosis to the pediatric tuberculosis division at Bellevue Hospital. Among adult patients the association is even much less. There were but 20 cases among 2,778 admissions for tuberculosis to the adult service at Bellevue in 1945; and at the New York Municipal Sanatorium at Otisville there were only 19 among 3,998 admissions from 1940 to 1948. Nevertheless every case of lymph node tuberculosis should be subjected to a thorough search for tuberculous foci elsewhere. While the nasopharynx may be the portal of entry it is quite probable that the neck nodes draining this area are infected by way of the blood or lymph streams from an infection originating in the lungs which may

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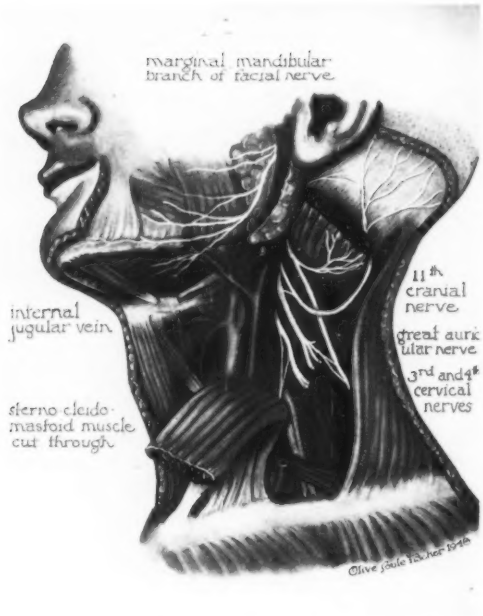
marginal mandibular branch of facial nerve
11th cranial nerve
great auricular nerve
3rd and 4th cervical nerves
internal jugular vein
sterno cleido mastoid muscle cut through
Olive Jöde Fisher 1948

Fig. 1. Important anatomical structures in the neck. The marginal mandibular branch of the facial nerve is often a little lower than depicted here. The eleventh cranial nerve usually traverses the sternomastoid muscle. It is exposed in the picture to make its course more evident. The nerves of the cervical plexus are sensory and may be cut without danger.

be healed, merely delitescent, or possibly active.

The pathology of lymph node tuberculosis need not be recounted. There are several features which should be mentioned however. Lymph node tuberculosis has an acute phase which corresponds to the exudative phase of pulmonary tuberculosis. Fibrous tissue around the nodes, perilymphadenitis, is a prominent feature of the disease. Liquefaction follows caseation and appears first within the node capsule from which it may rupture into the surrounding tissue to form a cold abscess and thence through the skin to form a sinus.

The clinical diagnosis offers little trouble. A firm swelling in the neck usually starting beneath the angle of the jaw which is tender at first but later painless and tends to extend rather than subside is probably tuberculosis. An acute infection in the same location subsides or suppurates in less than a month. The lymphomas feel more elastic and, while they may present a massive swelling, give the impression of being more discrete. The congenital cystic structures are stationary, do not tend to extend, and have typical locations.

Treatment of tuberculous lymphadenitis is determined by a consideration of the clinical and pathological situation in any particular case. In the exudative phase of the disease, i.e. while the nodes are tender and the patient toxic, bed rest and all the supportive treatment applied to pulmonary tuberculosis are indicated. This is especially true when the lymph node infection is merely a local manifestation of a systemic disease. To operate at such a time would only activate or accelerate the disease elsewhere and should not be done except in those rare instances in which the lymph node disease is having a deleterious effect on the systemic disease. Ultraviolet radiation, a popular form of treatment at one time, is probably of little real value and may do harm in the presence of a pulmonary lesion.

Roentgen therapy has a wide vogue. Unfortunately it is used in a haphazard fashion without due regard to its limitations, but when indicated it is a valuable adjunctive treatment. It cannot destroy the mycobacterium tuberculosis and is in no sense a sterilizing procedure. Nor can it cause the disappearance of a cold abscess or of caseation necrosis. Its chief effect is to produce fibrosis which is the method by which the body combats the infection. It is, therefore, of value early, before caseation necrosis has developed and late, when cold abscesses drain through chronic sinuses. Its use should be reserved to these indications and it will then be of great value. To continue irradiation of caseous nodes or of cold abscesses submits the patient to useless irradiation.

Streptomycin has recently come to the fore as a treatment for various types of tuberculosis but little has been written of its use on tuberculous lymph nodes except in a limited number of cases in the government hospitals of the Army, Navy, and Veterans' Administration. Here the reports are equivocal in that some nodes seemed to get smaller while others were unaffected. In no instance was the dis-

ease eliminated. Its use on tuberculous sinuses, however, has been strikingly good and most of these have healed under streptomycin therapy.

In considering streptomycin therapy certain facts must be borne in mind. First, the drug practically always produced toxic symptoms if given in the original dosage for a time adequate to produce therapeutic results. The smaller dose now employed has eliminated much of this trouble but it is always a possibility. Second, when the drug has been given for a variable length of time the organisms in the lesion are found to be streptomycin-fast. Whether this is due to the development of resistance in the organism or to the destruction of all the nonresistant strains leaving the resistant strains to take over makes little difference to us. Streptomycin can be used for only one full therapeutic course after which it loses its efficacy. Third, the drug is most effective in the acute exudative phase of tuberculosis and of scant value, or none at all, in the caseous and fibrotic phases of the disease.

Thus we do not advocate streptomycin as a therapeutic agent in the treatment of tuberculous lymphadenitis. Because caseation and fibrosis are prominent features in the disease streptomycin cannot be expected to produce favorable results. At the same time the use of streptomycin produces resistance in the infecting organism so that it will be without value in the treatment of an acute flare-up of the disease should this ever occur. We do advocate its restricted use as a prophylactic measure with surgery to prevent the spread or activation of the disease elsewhere.

The 12 cases in which we have used streptomycin have been in this category and in 11 of them the result was satisfactory. The 1 patient in whom the result was unfavorable had already had a long course of treatment with streptomycin for mediastinal nodes, and was presumably streptomycin resistant. One case was particularly interesting in that the child had quiescent lesions in bones and lungs which would ordinarily interdict operation. With prophylactic streptomycin the mass of broken down nodes in his neck that were retarding his recovery was removed without reactivation of any of the lesions and his improvement thereafter was rapid. One patient had multiple sinuses outside the area of operation which healed while streptomycin was being given.

Fig. 2. The common incisions. The lowest is seldom used but if this amount of exposure is necessary it leaves less scar than one along the sternomastoid.

In using streptomycin prophylactically our aim is to use enough to prevent reactivation or spread of the lesion but at the same time to avoid toxic symptoms and the production of an organism resistant to the drug. The daily dose of the drug is 10 milligrams per pound of body weight, up to 1 gram given in four divided doses. It is started the day before operation and discontinued not later than 2 weeks after operation. If the likelihood of spread seems small it is discontinued on the eighth day after operation. In this way toxic symptoms are avoided and we hope that the organism has not become drug-fast. We have not yet had occasion to find out by direct observation.

With all the new modalities for the treatment of accessible tuberculous nodes the treat-

ment of choice is still their *complete* removal in properly *selected* cases. Dowd and Hanford have shown this in the past and it is just as true today. Anything less than complete removal is inadequate. Aspiration or drainage of a cold abscess even with curettage of the caseous node is not complete removal. Careful selection is also essential. Operation in the acute phase is not to be considered any more than operation for pulmonary tuberculosis while the lesion is exudative. Nor is operation to be considered when the nodes are only the local manifestation of a systemic infection. To operate in such a situation is both futile and dangerous. Therefore, every case must be studied by x-ray, blood count, and sedimentation rate and by any other means necessary to rule out active lesions elsewhere.

The ideal time for operation is while the nodes are still relatively discrete. The formation of a cold abscess in the tissues around the nodes adds to the difficulty and the formation of a cutaneous sinus further complicates the situation. In neither instance is operation contraindicated provided the other conditions are favorable.

One of the objections raised to the surgical treatment of cervical lymphadenitis is the possibility of damage to important structures in the neck, chiefly the motor nerves. This is much more apt to happen in the presence of cold abscesses but can be avoided even then. For that reason it is important that the surgeon familiarize himself with the important anatomical structures in the neck, especially the marginal mandibular branch of the seventh nerve and the eleventh nerve. Figure 1 shows these structures.

The marginal mandibular branch of the seventh nerve crosses the angle of the mandible and lies just caudad to it as far as the facial vessels where it ascends onto the face. It lies beneath the platysma and on the deep cervical fascia. An incision a finger's breadth beneath the mandible will avoid it and if it is necessary to dissect upward the dissection must hug the capsule of the node. If injured it paralyzes the quadratus labii inferioris and interferes with puckering the mouth or smiling.

The eleventh nerve leaves the skull through the jugular foramen, crosses the transverse process of the atlas under the posterior belly of the digastric, and enters the upper third of the sternomastoid muscle to emerge at about the middle of the posterior border to supply the trapezius. It can be injured anywhere along its course. The landmark to use is the transverse process of the atlas and great care should be used when dissecting under the sternomastoid in this region. Nodes frequently surround it and every structure should be identified before it is severed. The nerve is fairly large and with care should always be identified.

The internal jugular vein is frequently surrounded by diseased nodes which must be dissected from it. The vein may be damaged but usually brisk venous bleeding comes from a tributary severed near the jugular vein and not the vein itself. This type of bleeding can be controlled by temporary packing. If the internal jugular vein is damaged it does no harm to ligate it.

Ether is the anesthetic agent of choice, administered through a nasal catheter or pharyngeal tube. This allows the anesthetist to keep out of the way. The use of a tube within the trachea is to be avoided. The trachea of a child is small and the manipulation of the surgeon in dissecting the nodes in the vicinity causes the tube to traumatize the trachea. Tracheitis is usual after the use of the endotracheal tube and in one of our patients tracheotomy was necessary.

Incisions should be made in or parallel to natural creases of the neck as shown in Figure 2. Longitudinal incisions heal with a broad scar which is unsightly. They are seldom necessary but should they be they are best made by extending a transverse incision upward next to the hair line as shown. The scar is less noticeable in this place. If a cutaneous sinus is present it should be excised in one of the standard incisions.

It should be stressed that the cardinal principle in the operation for the removal of tuberculous cervical nodes is the complete removal of all the diseased nodes. There is always much perilymphadenitis present which can effectually hide many diseased nodes. Before terminating the operation careful search should be made for these by palpation and by

direct vision. This cannot be emphasized too strongly. The removal of tuberculous cervical lymph nodes is a slow and tedious process requiring the time and patience to do a thorough job. It is not an operation to be turned over to an inexperienced resident without careful supervision. Diseased nodes left behind enlarge rather promptly and necessitate a secondary operation for their removal. A certain number of secondary operations are unavoidable but most of them can be prevented by careful removal of the nodes at the time of the original operation.

After the incision has been made as described it is deepened down through the platysma to the node. The fibrous tissue around the node is densely adherent to the capsule and tends to obliterate the cleavage plane which must be defined by sharp dissection. To obtain the proper exposure the node must be grasped in Kocher or in Lahey goiter clamps. More traction must be exerted than will permit the use of an Allis clamp. In dissecting the nodes out we prefer modified curved Mayo scissors with thin narrow tips. The dissection is kept well up on the node as close to it as possible, and the adhesions are spread with the scissors and then snipped. This requires sharp scissors which cut to the end (Fig. 3).

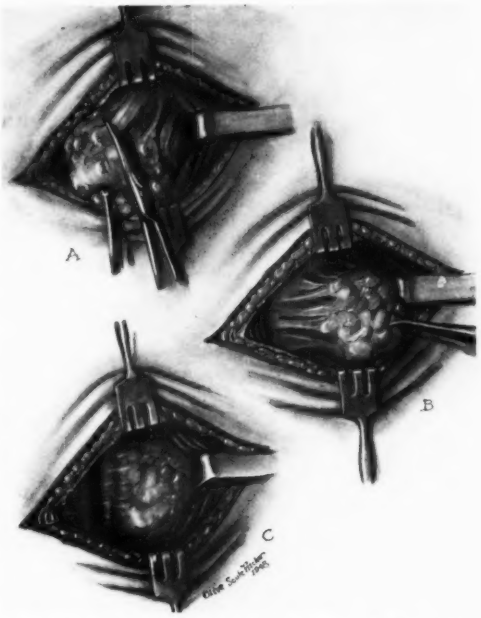

Fig. 3. Technique of lymph node dissection. A, The adhesions to the node are divided well up on the node. B, Traction exposing the adhesions but also hiding a large vessel which becomes apparent when the traction is released as in C.

Traction on the mass should be relaxed frequently and the adjacent tissues carefully inspected for blood vessels and nerves. Tension empties the veins and makes them indistinguishable until they are cut and bleed (Fig. 3 b and c), and nerves under tension look like fibrous tissue. After working in one direction for some time the operator may find that he is in a deep recess where exposure is poor. The mass should then be attacked from another direction which will make it easier to identify important structures and to maintain orientation.

Cold abscesses are frequently encountered and contamination of the wound by tuberculous pus is of no consequence. If the cold abscess is confined to the node the dissection can be carried on without regard to it. If the cold abscess is in the tissues the wall of the cold abscess must be excised as well as the underlying nodes which are responsible for it. This is a difficult procedure during which injury to the nerves and blood vessels can easily occur. If there is a draining cutaneous sinus the same surgical principle holds. With the use of penicillin most of these wounds heal promptly.

The wound is closed by suturing the platysma first and then the skin. We usually place a small piece of rubber dam or a seton of silkworm gut in the wound to take care of the fluid forming in the dead space. This is removed the first day after operation and fluid which collects after that is removed by aspiration through normal skin. The wound should never be probed or otherwise opened unless there is frank pyogenic infection. The patient is allowed out of bed the day after operation; the sutures are removed on the fifth day; and the patient discharged the following day.

Complications are chiefly those which have to do with injury to one of the motor nerves and the marginal mandibular branch of the

seventh nerve is the one most commonly injured. When the nerve traverses the wall of a cold abscess it is hard to identify. In such a case it is better to leave part of the wall and trust to streptomycin to heal the wound. Most of the injuries to the seventh nerve are caused by too vigorous retraction and such injuries are of only short duration.

Sinuses and recurrences are complications resulting from incomplete removal of the diseased nodes. Most of them can be avoided by careful surgery but the complications are sure to occur now and then. Recurrent nodes should be operated upon again. Sinuses result from caseous material in the wound, usually an overlooked node. The node should be removed but if it is not apparent x-ray therapy or streptomycin are potent agents in closing sinuses. Sinuses due to a mixed infection should have penicillin treatment as well. An acute activation of tuberculosis following operation for tuberculous lymph nodes means that an active focus was overlooked before operation. It should never happen.

Results have been uniformly good. Some patients have had to be operated upon again and we have had to use x-ray therapy to close an occasional sinus. The antibiotics give us a great advantage which was denied to the older surgeons and, if the disease is not allowed to drag on too long before coming to operation, our results should be much better than theirs. This will happen when the advantages of surgical treatment are as well recognized as they were 30 years ago.

SUMMARY

1. Tuberculosis of the cervical lymph nodes is much less common than it was in an earlier generation and its character has changed.

2. Surgical removal of the involved nodes is the most satisfactory form of treatment. General hygienic measures and x-ray therapy are valuable adjuvants.

3. The judicious use of streptomycin is promising.

REFERENCES

1. Barrington-Ward, L. Lancet, Lond., 1937, 1: 980.
2. Dowd, C. N. J. Am. M. Ass., 1916, 67: 499.
3. Erskine, A. W. Practical X-ray Treatment. P. 109. St. Paul and Minneapolis: Bruce Publishing Co., 1947.
4. Evans, E. S. Tubercle, Lond., 1939, 20: 510.
5. Franklan, C., Pugh, G., Windeyer, B. W., and Turner, G. Proc. R. Soc. M., Lond., 1937, 31: 103.
6. Hanford, J. M. Treatment of Tuberculosis of Cervical Lymph Nodes. P. 118A. Nelson New Loose-leaf Surgery. New York: Thomas Nelson & Sons, 1933.
7. Kaplan, I. A. Radiation Therapy. P. 453. New York: Oxford University Press, 1937.
8. Report of the Council on Pharmacy and Chemistry. J. Am. M. Ass., 1947, 135: 634.
9. Annual report of the Committee on Therapy and the Subcommittee on Streptomycin. J. Am. M. Ass., 1947, 135: 641.
10. Thompson, B. C. Brit. M. J., 1936, 2: 584.

THE SURGICAL ANATOMY OF CYSTOCELE AND URETHROCELE WITH SPECIAL REFERENCE TO THE PUBOCERVICAL FASCIA

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A LARGE majority of gynecologists and general surgeons believe that there is in the human female pelvis a layer of closely felted fascia which, it is alleged, is attached to the posterior surface of the body of the os pubis along its lower border and to the cervix uteri a short distance above the external os. Some contend that this layer of fascia is situated just beneath the vaginal mucosa and that it surrounds the vagina, while others believe that it separates the vaginal wall from the walls of the bladder and the urethra and that it extends laterally to become continuous with the fascia endopelvina. This layer of fascia has been termed the pubocervical fascia. Synonymous terms are pubouterine fascia, pubovesicocervical fascia, and musculofascia.

The group who believe that the pubocervical fascia is an anatomic entity contend that a congenital defect in it or an obstetric injury to it is the basic cause of cystocele and urethrocele. They reason logically, therefore, that a successful surgical correction of a cystocele or urethrocele depends upon the reconstruction of the defective or damaged part of the pubocervical fascia. It is important to keep clearly in mind the fact that such a concept of the etiology and surgical correction of cystocele and urethrocele is based entirely upon empiric observations made during operations on the living subject or gross dissections on the cadaver.

In view of the fact that authoritative anatomists do not mention the pubocervical fascia and that a considerable number of gynecologists are completely convinced that there is no such fascia in the human pelvis, it is important to review the anatomic and histologic facts upon which their conviction is based. It is obvious that it is possible to form a clear concept of the etiology of cystocele and urethrocele and of the histologic character of the tissues involved in their surgical correction only upon such facts.

To correlate the evidence against the existence of the pubocervical fascia it is necessary to consider: (1) the attachments of the vagina, the urinary bladder, and the urethra; (2) the histology of the normal vaginal, bladder, and urethral walls; and (3) the normal vesicovaginal and urethrovaginal septa.

THE ATTACHMENTS OF THE VAGINA

The vagina is attached at its upper extremity to the cervix uteri a short distance above the external os. The muscular coat of the vaginal wall blends with the musculature of the cervix and its mucosa is continuous with the mucosa of the portio. At its lower extremity the vagina penetrates and is attached to the urogenital trigone by its muscular coat. The vaginal mucosa and the mucosa of the introitus are continuous. The anterior vaginal wall above the urogenital trigone fuses so intimately with the posterior urethral wall that there is no line of normal cleavage between them. At a higher level the anterior vaginal wall is loosely attached to the wall of the bladder by a delicate layer of areolar connective tissue which marks a line of natural cleavage between the muscular coat of the vaginal wall and the muscular coat of the bladder wall. The posterior vaginal wall above the urogenital trigone fuses with the upper part of the wall of the anal canal and at a higher level it is attached to the anterior rectal wall by a delicate layer of areolar connective tissue which marks a line of normal cleavage between the muscular coat of the vaginal wall and the muscular coat of the rectal wall. Laterally the vaginal walls are attached to the visceral part of the

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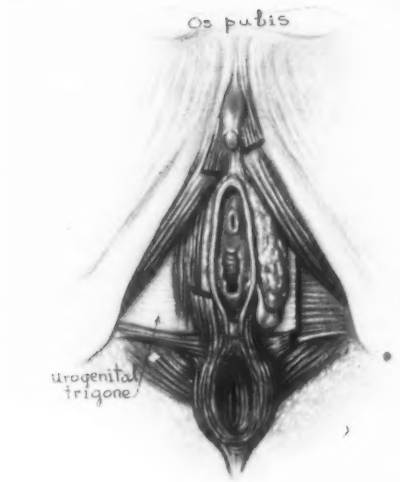

Fig. 1. The urethra and vagina penetrate and are attached to the urogenital trigone below the os pubis. Any layer of fascia which might traverse the length of the anterior vaginal wall or separate the vaginal wall from the walls of the urethra and the bladder would have to be attached at its lower extremity to the urogenital trigone. The term pubocervical fascia, which indicates an attachment of the fascia to the pubic bone, is inaccurate.

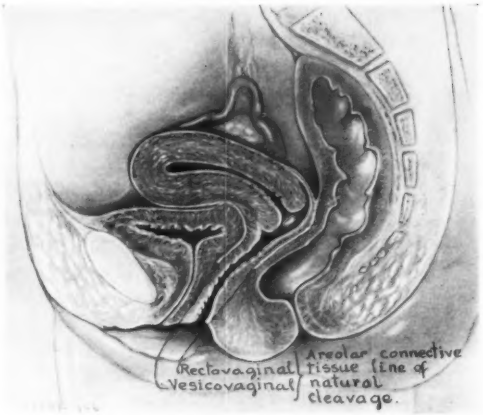

Fig. 2. Lateral view of the pelvis showing the natural cleavage planes and the penetration of the urogenital trigone by the urethra and vagina below the pubic bone.

fascia endopelvina which is continuous with the vesicovaginal and rectovaginal areolar connective tissue.

THE ATTACHMENTS OF THE BLADDER

The "ligaments" of the bladder are described as true and false, under the latter being included the peritoneal folds that pass from the organ to the adjacent abdominal and pelvic walls. From the manifest instability of relations and attachments of the peritoneum incident to distention and contraction, it is evident that such peritoneal folds can contribute little to the definite support or fixation of the bladder; hence, those parts of the organ possessing a serous covering are movable. The inferior surface, on the contrary, is comparatively fixed on account of its close relations to the pelvic floor and the presence of *true ligaments*. These are derived from the pelvic fascia, which in the vicinity of the bladder presents a stout, glistening, band-like thickening (arcus tendineus) that on each side stretches from the posterior surface of the symphysis, a short distance above its lower border, backward to the ischial spines. On either side of the midline the anterior ends of these tendinous arches pass as strong fascial bands from the symphysis to the bladder as *anterior true ligaments*. After leaving the symphysis, the tendinous arches send expansions—the *lateral true ligaments* to the sides of the bladder (Piersol). The posteroinferior surface of the bladder is loosely attached to the vaginal wall and to the uterus by a delicate layer of areolar connective tissue.

THE ATTACHMENTS OF THE URETHRA

At its upper extremity the urethra penetrates the wall of the bladder, and its muscular coat blends with the musculature of the bladder wall. At its lower extremity the urethra penetrates and is attached to the urogenital trigone by its muscular coat. The urethral mucosa blends with the vesical mucosa and that of the introitus. The anterior urethral wall is attached to the connective tissue in the floor of the space of Retzius. The posterior urethral wall above the urogenital trigone is intimately attached to the anterior vaginal wall. Laterally the urethral wall is attached to the fascia endopelvina.

With the attachments of the walls of the vagina, bladder, and urethra clearly in mind

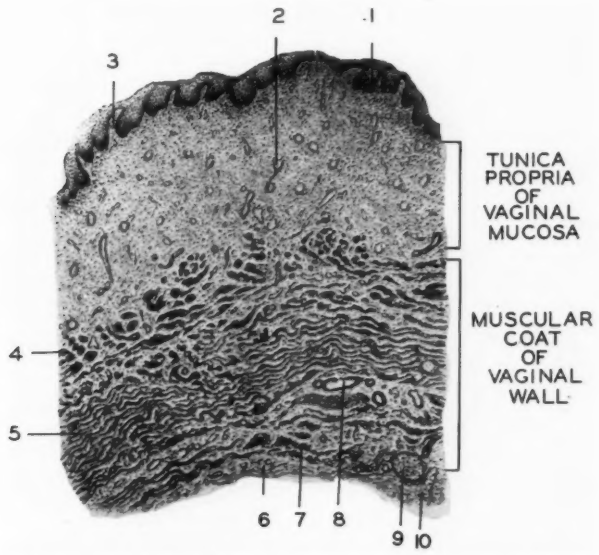

Fig. 3. Longitudinal section of the normal vaginal wall. *1*, Vaginal epithelium; *2*, tunica propria of vaginal mucosa; *3*, papilla; *4*, internal circular muscle layer; *5*, external longitudinal muscle layer; *6*, fibrous layer; *7*, interstitial connective tissue; *8*, artery in muscle; *9*, ganglion; *10*, fat lobules. (From Maximow.)

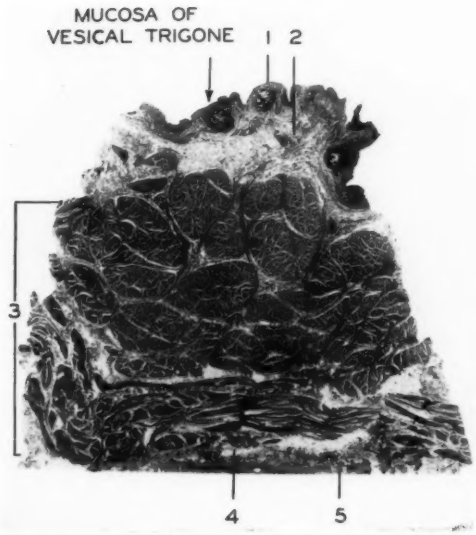

Fig. 4. Section of normal bladder wall. *1*, Transitional epithelium of vesical mucosa; *2*, tunica propria of vesical mucosa; *3*, muscular coat of bladder wall; *4*, fibrous coat; *5*, vesicovaginal areolar connective tissue. (From Goff.)

it is apparent that any layer of fascia which might traverse the full length of the vaginal wall, or which might separate the vaginal wall from the walls of the bladder and urethra would have to be attached at its lower extremity to the urogenital trigone below the pubic bone (Figs. 1 and 2). It is obvious, therefore,

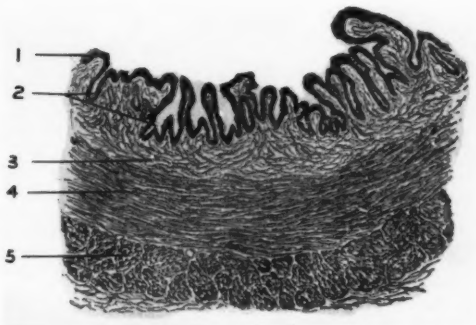

Fig. 5. Longitudinal section of normal urethral wall. *1*, Urethral epithelium; *2*, urethral glands; *3*, tunica propria of urethral mucosa; *4*, longitudinal muscular layer; *5*, circular muscular layer. (From Piersol.)

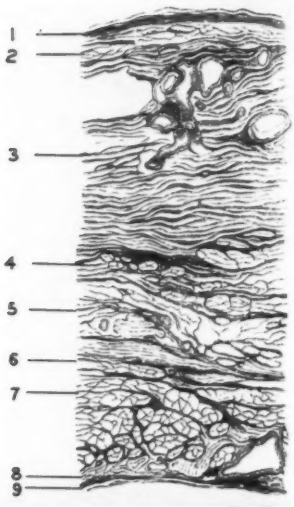

Fig. 6. Horizontal section of the posterior wall of the bladder and the anterior wall of the vagina. *1*, Epithelium of the bladder; *2*, mucosa of the bladder, *3*, circular muscular layer of the bladder wall; *4*, longitudinal muscular layer of the bladder wall; *5*, loose connective tissue; *6*, circular muscular layer of the vaginal wall: *7*, longitudinal muscular layer of the vaginal wall; *8*, mucosa of vagina; *9*, epithelium of vaginal wall. (From Jacob Henle.)

that the term pubocervical fascia, which undoubtedly indicates an attachment to the pubic bone, is inaccurate. In behalf of accuracy in the teaching of vaginal plastic surgery it is important to eliminate the term pubocervical fascia and its synonyms from gynecological nomenclature.

HISTOLOGY OF THE NORMAL VAGINAL WALL

The normal vaginal wall (Fig. 3), from 2 to 3 millimeters thick, includes a *mucous* and a *muscular coat*, supplemented externally by an indefinite *fibrous coat*.

The mucous coat consists of a fibroelastic tunica propria, exceptionally rich in elastic fibers and veins, the inner surface of which is beset with numerous conical papillae that encroach upon the overlying epithelium, but do not model the free surface. The epithelium, from 0.15 to 0.20 millimeter thick, is stratified squamous in type.

The muscular coat, which directly supports the mucosa without the intervention of a submucous tissue, consists of bundles of involuntary muscle that are arranged, although not with precision, as an inner circular layer and an outer longitudinal layer.

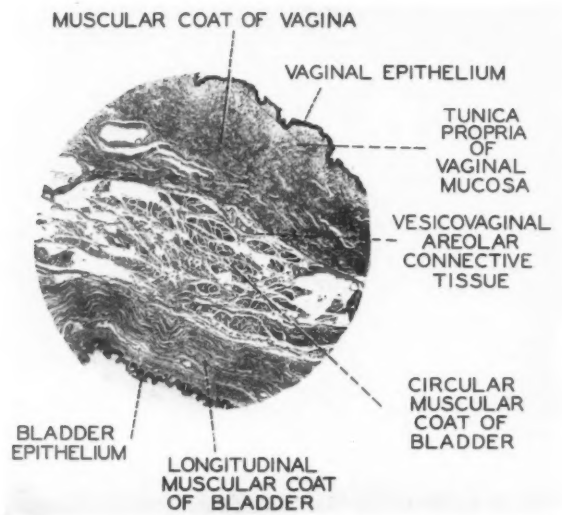

Fig. 7. Low power view of a section through the adjacent walls of the bladder and vagina. (From W. Blair Bell.)

The fibrous coat consists of a thin layer of connective tissue which merges into the areolar connective tissue which joins the vagina to the surrounding parts (Piersol). The fibrous coat is in reality a condensation of the vesicovaginal areolar connective tissue.

HISTOLOGY OF THE NORMAL BLADDER WALL

The normal bladder wall (Fig. 4) consists of four coats: the mucous, the submucous, the muscular, and the fibrous.

The mucous coat varies in thickness with both location and the degree of contraction. Over the vesical trigone, where always comparatively smooth, it is thin, measuring only about .1 millimeter; where strongly wrinkled by contraction, it may attain a thickness of 2 millimeters. The mucosa resembles closely that of the renal duct, consisting of a fibroelastic tunica propria covered with transitional epithelium.

The submucous coat, loose and elastic, permits free gliding of the mucous over the muscular tunic when readjustment becomes necessary during contraction. It is not sharply defined from the adjoining coats, but blends with the stroma of the mucosa on the one side and extends between the tracts of the muscu-

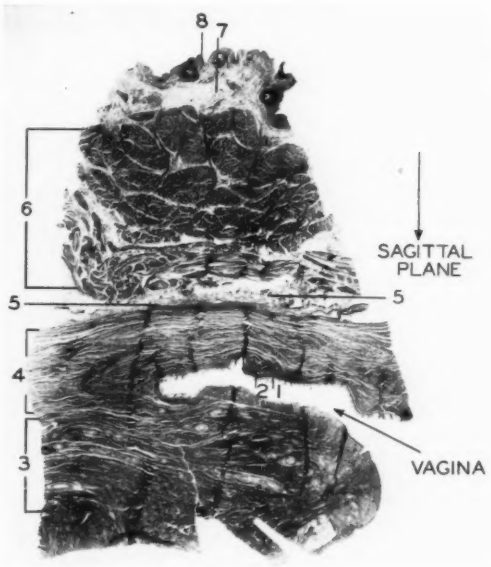

Fig. 8. Section through the normal vesicovaginal septum. *1*, Epithelium of vaginal mucosa; *2*, tunica propria of vaginal mucosa; *3*, muscular coat of posterior vaginal wall; *4*, muscular coat of anterior vaginal wall; *5*, Vesicovaginal areolar connective tissue; *6*, muscular coat of bladder wall; *7*, tunica propria of bladder mucosa; *8*, epithelium of bladder mucosa. (From Goff.)

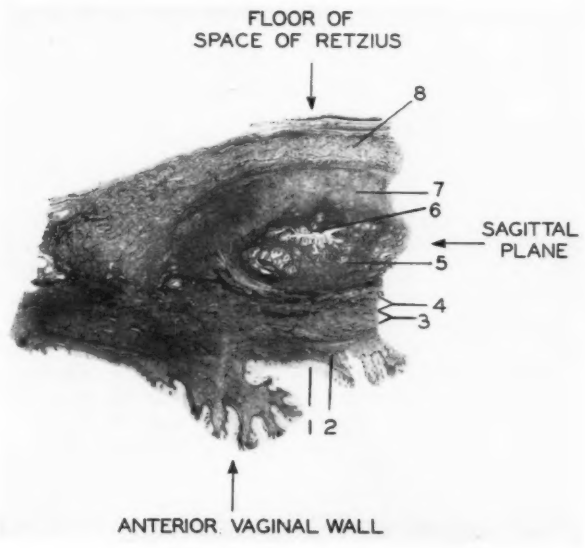

Fig. 9. Section through the normal urethrovaginal septum at a level just above the point at which the urethra penetrates the urogenital trigone. *1*. Epithelium of vaginal mucosa; *2*, tunica propria of vaginal mucosa; *3*, muscular coat of vaginal wall; *4*, muscular coat of urethral wall; *5*, tunica propria of urethral mucosa; *6*, epithelium of urethral mucosa; *7*, muscular coat of urethral wall; *8*, voluntary muscle fibers of urethral wall. (From Goff.)

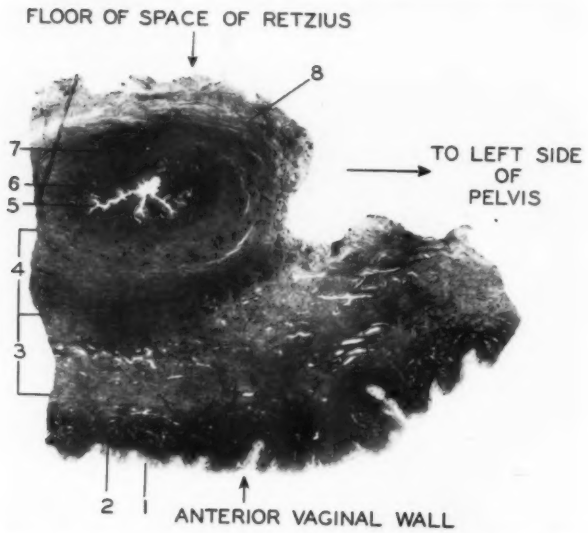

Fig. 10. Section through the normal urethrovaginal septum at a level just above the point at which the urethra penetrates the urogenital trigone. *1*, Epithelium of vaginal mucosa; *2*, tunica propria of vaginal mucosa; *3*, muscular coat of vaginal wall; *4*, muscular coat of urethral wall; *5*, epithelium of urethral mucosa; *6*, tunica propria of urethral mucosa; *7*, muscular coat of anterior urethral wall; *8*, voluntary muscle fibers of anterior urethral wall. (From William H. F. Addison.)

lar coat on the other. Beneath the trigone a distinct submucous layer is wanting or is replaced by a sheet of muscular tissue.

The muscular coat, thicker than the mucous, varies according to the condition of the bladder, being thin during distention and thick in strong contraction, when it may measure as much as 1.5 centimeters. The bundles of involuntary muscle are arranged in two fairly distinct layers—a thin outer longitudinal and a thick inner circular layer. Inside the latter, and virtually within the submucosa, lies an incomplete additional layer. This innermost layer is represented by isolated and indefinite muscular bundles that are blended with the connective tissue. Over the vesical trigone, however, this layer becomes condensed and forms a compact transverse muscular sheet that is closely united to the overlying mucous membrane and, in conjunction with the muscular tissue of the urethra, surrounds the beginning of that canal with a constrictor-like tract, the internal vesicle sphincter.

The outer fibrous coat is strongest over the inferior surface where it receives reflections from the fascia endopelvina. Over the posteroinferior surface it blends with the vesicovaginal areolar connective tissue (Piersol).

HISTOLOGY OF THE NORMAL URETHRAL WALL

The wall of the normal female urethra (Fig. 5) consists of a mucous membrane supplemented by an outer muscular tunic.

The mucous membrane is composed of a tunica propria, rich in elastic fibers and provided with a highly developed system of venous plexus, covered with stratified squamous epithelium that above resembles the vesical type and below that of the vestibule. Urethral glands are represented by small groups of tubular alveoli that open by minute orifices on the mucous surface. The mucosa is also beset with small pit-like depressions into which the ducts of the glands frequently open.

The muscular coat of the urethra comprises intrinsic unstriped fibers and extrinsic striated

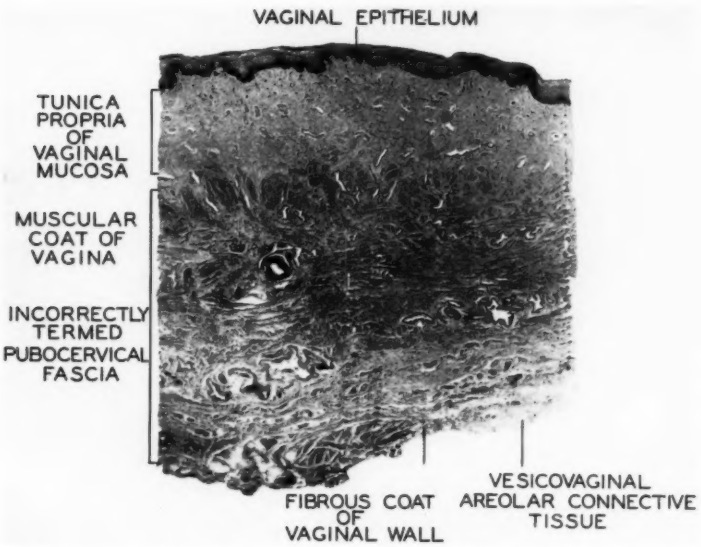
VAGINAL EPITHELIUM
TUNICA PROPRIA OF VAGINAL MUCOSA
MUSCULAR COAT OF VAGINA
INCORRECTLY TERMED PUBOCERVICAL FASCIA
FIBROUS COAT OF VAGINAL WALL
VESICOVAGINAL AREOLAR CONNECTIVE TISSUE

Fig. 11. Section of anterior vaginal wall in a case of large cystocele taken from the lateral part of the wall midway between the urogenital trigone and the cervix.

fibers which are situated outside the unstriped fibers. The unstriped fibers are arranged in an inner longitudinal and an outer circular layer, the two being separated by an intervening stratum of areolar tissue (Piersol). The striped fibers are located on the anterior and lateral walls and are absent on the posterior wall—the wall adjoining the anterior vaginal wall. At the extremities of the urethra they form sphincters.

A perusal of the authoritative texts on histology reveals the fact that histologists are unanimously agreed on the histology of the vaginal wall, the bladder wall and the wall of the urethra. In no instance has any histologist described a layer of closely felted fascia in the walls of the vagina, the urinary bladder, or urethra. It is apparent, therefore, that gynecologists who contend that there is a layer of closely felted fascia in the vaginal wall just beneath the mucosa ignore irrefutable histologic facts.

THE NORMAL VESICOVAGINAL SEPTUM

Ricci, in an exhaustive review of the literature, calls attention to the fact that Jacob Henle, in 1866, first described the normal, intact vesicovaginal septum. Henle published a hand drawing of a cross section through the intact septum (Fig. 6), in which he illustrates all of the tissues from the vaginal epithelium to the epithelium of the bladder. This drawing clearly demonstrates that there is no layer of closely felted fascia in the vesicovaginal septum. It does show, however, that there is between the muscular coat of the vaginal wall and the muscular coat of the bladder wall a delicate layer of areolar connective tissue. Referring to this tissue, as illustrated by Henle, Ricci has stated: "His text contains a hand drawing of the microscopy of the *fascia vesicovaginalis*— a *loose areolar mesh*." Because of the fragile character of this vesicovaginal areolar connective tissue it is not involved in the etiology of cystocele. In the surgical correction of a cystocele its only role is to guide the operator along a line of natural cleavage between the muscular coat of the vaginal wall and the muscular coat of the bladder wall. It cannot be dissected as an individual layer and it cannot be sutured in operations for cystocele. Henle's description of the vesicovaginal

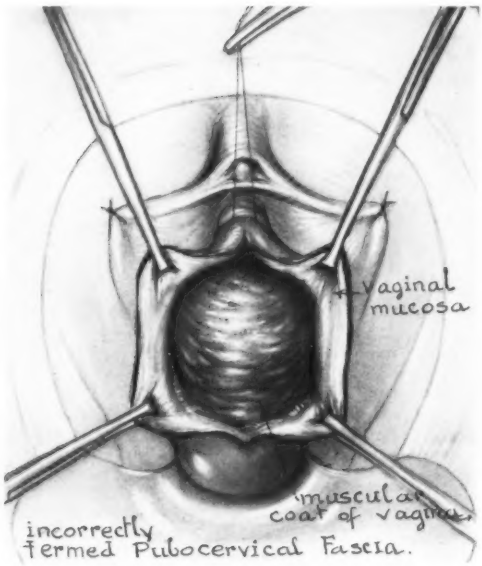

Fig. 12. Operation for cystocele (Type 2). Step 1. The vaginal mucosa is dissected from the underlying muscular coat of the anterior vaginal wall (incorrectly termed pubocervical fascia).

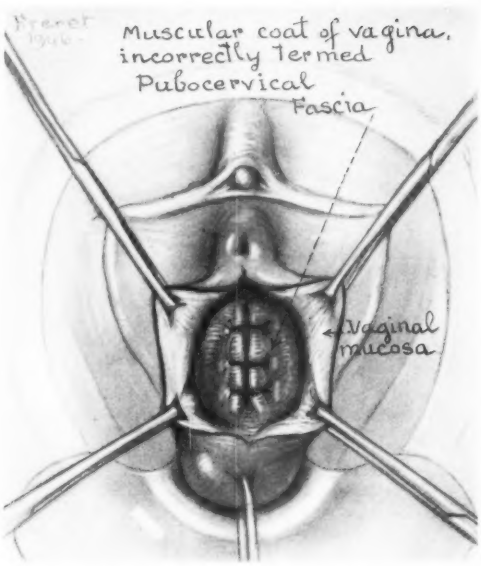

Fig. 13. Step 2. The redundant muscular coat of the vaginal wall is inverted by interrupted sutures. The excessive part of the vaginal mucosa is removed and the cut edges are approximated in the sagittal plane of the body.

septum was corroborated by W. Blair Bell, (Fig. 7), in 1910, by Goff (Fig. 8), in 1931, and by Koster, in 1936.

THE NORMAL URETHROVAGINAL SEPTUM

The structure of the urethrovaginal septum (Fig. 9 and Fig. 10) differs from that of the vesicovaginal septum in one important respect. Between the muscular coat of the vagnal wall and that of the bladder wall there is a layer of areolar connective tissue which is absent in the urethrovaginal septum. In the urethrovaginal septum the muscular coat of the vaginal wall and the muscular coat of the urethral wall fuse so intimately that there is present no line of natural cleavage between them.

Along the line of this fusion there is a considerable amount of interfascicular connective tissue which tends to make the union an extremely firm one. There is no fascia between the wall of the urethra and the wall of the vagina. This fact alone makes the existence of the pubocervical fascia impossible.

THE HISTOLOGY OF THE VAGINAL WALL IN CYSTOCELE

The vaginal wall in which there is a cystocele or urethrocele has a characteristic structure (Fig. 11). Contrary to the general opinion, the vaginal wall is hypertrophied in all of its layers. This hypertrophy is proportional to the size of the cystocele. In the case of an extremely large cystocele of long standing the vaginal wall may range from 0.5 to 1 centimeter in thickness. As a rule the wall is not as thick in the sagittal plane as it is in the lateral part. In either part, however, there is a thickening of the epithelial layer, a moderate degree of hypertrophy of the tunica propria, and a remarkable hypertrophy of the muscular coat in which there is both a numerical and an individual hypertrophy of the irregularly arranged muscle fibers. In the muscular coat there is also a considerable amount of interfascicular connective tissue. There is a slight increase in the amount of connective tissue in the fibrous coat which is in reality a condensa-

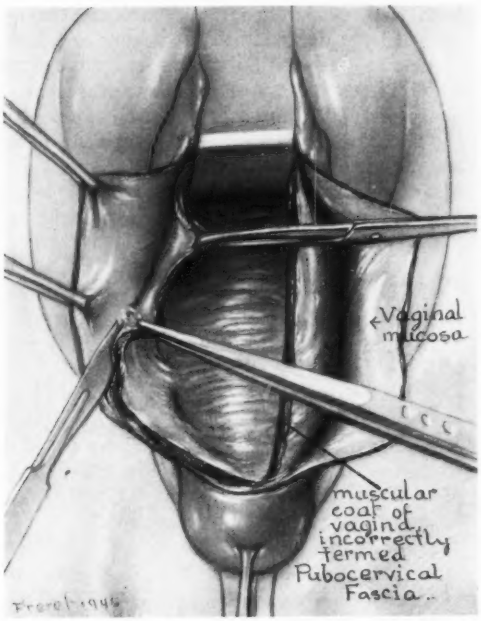

Fig. 14. Operation for cystocele (Type 3). Step 1. The vaginal mucosa is dissected from the underlying muscular coat of the anterior vaginal wall (incorrectly termed pubocervical fascia). The bladder has been separated from its abnormal vaginal and uterine attachments.

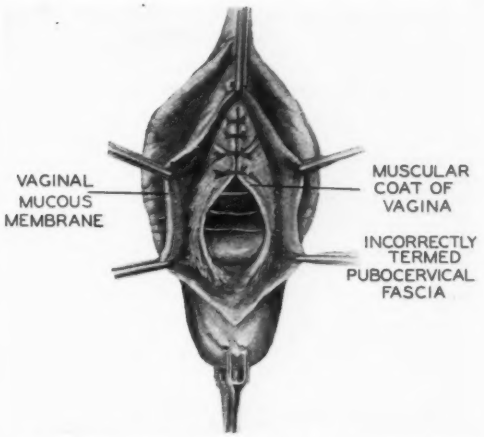

Fig. 15. Step 2. The muscular coat of the anterior vaginal wall (incorrectly termed pubocervical fascia) is sutured in the sagittal plane after the removal of the redundant part. The excessive part of the vaginal mucosa is removed and the cut edges are approximated in the sagittal plane of the body. (From E. Martin.)

tion of the vesicovaginal areolar connective tissue.

To the modified muscular coat of the vaginal wall in cystocele the term musculofascia has been incorrectly applied. The inaccuracy of such a term is apparent when one realizes the fact that this coat consists of approximately 80 per cent smooth muscle fibers. The irregularly arranged interfascicular connective tissue found in this layer does not constitute a fascia in any sense of that term. Bissell, in 1929, deplored the application of the term fascia to the modified muscular coat of the vaginal wall in cases of cystocele.

The above description of the histologic changes in the vaginal wall in cystocele has been based upon the histologic examination of sections which include all tissue from the vaginal epithelium to the fibrous coat of the bladder. These sections have been made at various levels and locations in the vesicovaginal septum in cases of cystocele of all degrees of size.

CLASSIFICATION OF OPERATIONS FOR CYSTOCELE AND URETHROCELE

The vaginal operative procedures for the correction of cystocele and urethrocele in which the principal feature has been the utilization of the so called pubocervical fascia are of four types: (1) A type of operation in which the vaginal mucosa is denuded over a geometric design and the redundant part of the pubocervical fascia is infolded by sutures which also approximate the cut edges of the vaginal mucosa. Sims, Emmett, and their contemporaries employed this type of operation. (2) A type of operation (Figs. 12 and 13) in which bilateral flaps of vaginal mucosa are dissected from the redundant pubocervical fascia which is then inverted by sutures. The excessive part of the mucosal flaps is removed and the cut edges are approximated in the sagittal plane of the body. (3) A type of operation (Figs. 14 and 15), in which the vaginal wall is opened in the sagittal plane from a point 1.5 centimeters posterior to the urinary meatus to a point at the level of the cervicovaginal junction by an incision which passes

through the mucosa and the pubocervical fascia to the line of natural cleavage between the vaginal wall and the bladder wall. Along this line of cleavage the bladder wall is separated from its abnormal vaginal and uterine attachments. Following the mobilization of the bladder wall the mucosa is separated by sharp dissection from the pubocervical fascia which is then sutured in the sagittal plane as an individual layer. The mucosa, after the removal of the redundant part, is sutured in the sagittal plane as an individual layer over the reconstructed pubocervical fascia. And (4) a type of operation in which the vaginal wall is opened in the sagittal plane from a point 1.5 centimeters posterior to the urinary meatus to a point at the level of the cervicovaginal junction by an incision which passes through both mucosa and pubocervical fascia to the line of normal cleavage between the vaginal wall and the bladder wall. The bladder wall is then separated from its abnormal vaginal and uterine attachments. Following the mobilization of the bladder wall the redundant part of the vaginal mucosa and the pubocervical fascia is removed as a single layer and the cut edges are united in the midline as one layer.

In the above descriptions of operations, the term pubocervical fascia is incorrectly applied to the muscular coat of the vaginal wall.

The anatomic and histologic facts herein enumerated are agreed upon by all authoritative anatomists and histologists. They constitute proof positive that there is no closely felted layer of fascia in or between the walls of the vagina, the urinary bladder, or the urethra. They show that there is a delicate layer of areolar connective tissue between the vaginal wall and the bladder wall which, because of its fragile structure is not involved in the etiology of cystocele. It is apparent, therefore, that cystocele and urethrocele are not caused by a defect in or an injury to a layer of fascia. It is equally apparent that those who believe that the pubocervical fascia is an anatomic entity must revise their concept of the etiology of cystocele and urethrocele if they are inclined to conform to firmly established histologic facts. The etiology of cystocele and urethrocele is a subject for future discussion.

CONCLUSIONS

1. There is no fascia in the walls of the vagina, the urinary bladder, or the urethra.
2. There is no fascia between the vaginal wall and the urethral wall.
3. Between the wall of the vagina and the wall of the bladder there is a delicate layer of areolar connective tissue which, because of its frail structure, is not involved in the etiology of cystocele. There is no layer of closely felted fascia in the vesicovaginal septum.
4. The term "pubocervical fascia" has been incorrectly applied to the muscular coat of the vaginal wall.
5. There is no pubocervical fascia in the human pelvis.

REFERENCES

1. Addison, W. F. Personal communication, 1931.
2. Bell, W. Blair. Principles of Gynecology. London: Longmans, Green & Co., 1910.
3. Bissell, Dougal. Surg. Gyn. Obst., 1929, 48: 549.
4. Goff, Byron H. Surg. Gyn. Obst., 1931, 52: 32.
5. Henle, Jacob. Handbuch der systematischen Anatomy des Menschen. Vol. II, p.446. Braunschweig: F. Veiweg & Sohn. 1866.
6. Koster, H. Am. J. Obst. Gyn., 1933, 25: 67.
7. Martin, Eduard. Der Haftapparat der weiblichen Genitalien. Vol. 2. Berlin: S. Karger, 1912.
8. Maximow. Textbook of Histology. Philadelphia: W. B. Saunders Co., 1930.
9. Piersol. Human Anatomy. Philadelphia and London: J. B. Lippincott Co.
10. Ricci, J. V., and Marr, J. P. Principles of Extraperitoneal Caesarean Section. P. 103. Philadelphia: The Blakiston Co., 1942.

STUDIES ON ECK FISTULAS IN DOGS

A Simple Technique for the Preparation of a Portacaval Anastomosis with the Aid of a Clamp

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PORTACAVAL anastomosis has been used as a means of studying the role of the portal circulation in the maintenance of liver function. The procedure is of current interest as a means of reducing portal hypertension in patients with cirrhosis of the liver. By the obstruction of the portal vein above this anastomosis, it is possible to deprive the liver of approximately two-thirds of its blood supply. However, the response of dogs which have had Eck fistulas made varies considerably; some animals can be maintained in good condition for several years (1), while others rapidly lose weight after the anastomosis is formed (2). It is apparent to one who has made this anastomosis by the cutting suture technique as described by Fishback that the size and patency of the stoma in different animals may vary considerably as a result of the anatomical variations in the relation of the portal vein to the inferior vena cava and of differences in the shape of the chest, factors which influence the accessibility of these structures to the surgeon. Postmortem examinations at different intervals after Eck fistula formation reveal that in some animals the anastomosis remains patent, while in others it tends to grow shut or to be greatly narrowed. These observations prompted a search for a more uniform and reproducible means of forming a communication between the two vessels in question. Theoretically, it seems preferable to have a stoma of fixed and invariable size. To secure such a stoma, however, would entail the use of a foreign object, such as a vitallium cuff, and its use would make the operation technically difficult in the dog. Since few foreign objects are well tolerated by the tissues over an extended period of time, it was decided to seek a method of producing a more satisfactory stoma between two vessels without connecting them by means of a foreign object.

To assist in this purpose a clamp was necessary which would enable fixation and maintenance of the two vessels in definite relation to one another, which would exclude blood from the operative field without completely obstructing either vessel, and which could be applied from the ventral surface of the vessels without extensive dissection or mobilization of them. The blood vessel clamps already described in the literature seemed unsuitable for this purpose. An attempt to use the Potts-Smith (4) clamp for this purpose was unsuccessful.

The clamp which was devised fulfills the three requirements mentioned. However, practically complete occlusion of the portal vein may occur if the vessel is unusually small, or if the relation between the two vessels is such that the anastomosis must be made distal to its usual location on the portal vein. Once the clamp is securely applied one can incise the vessels and form the anastomosis without hurry or blood loss. By means of this procedure portacaval anastomosis has been made in approximately 30 dogs. Some of these animals were used in the Eck or reverse Eck fistula experiments, while in other instances the anastomosis was part of a one stage hepatectomy as described by Markowitz.

PROCEDURE

Usually dogs weighing 30 pounds or more are used for this operation. With the anesthetized animal secured on his back, the surgeon makes a midline abdominal or right rectus incision from the ensiform process to the penis of the male dog, or one slightly longer in the female animal. The intestines are retracted to the left side of the abdomen and

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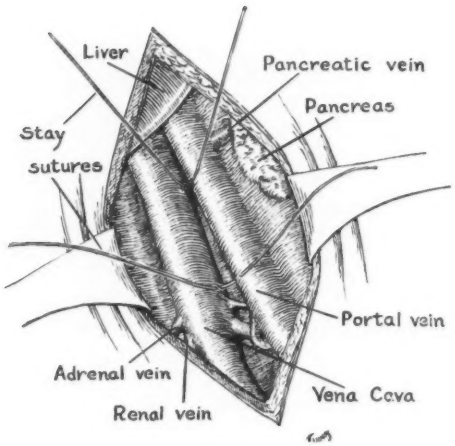

Fig. 1.

Figs. 1 to 7 show the technique of making a portacaval anastomosis with clamp.

are covered with a laparotomy pad. The hepatorenal ligament is cut and a laparotomy pad is placed over the surface of the liver and the left side of the incision.

The peritoneum, fat, lymphatic and fine blood vessels overlying the portal vein are completely cleared by blunt dissection from that portion of the portal vein which lies next to the vena cava. The vena cava above the renal vein and below the liver is freed of fat and peritoneal attachments on the side next to the portal vein. After both vessel walls have been carefully exposed and cleared of overlying

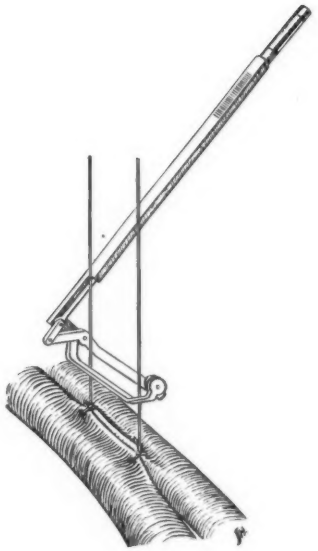

Fig. 2.

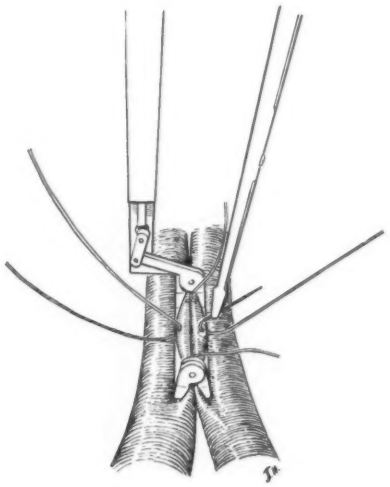

Fig. 3.

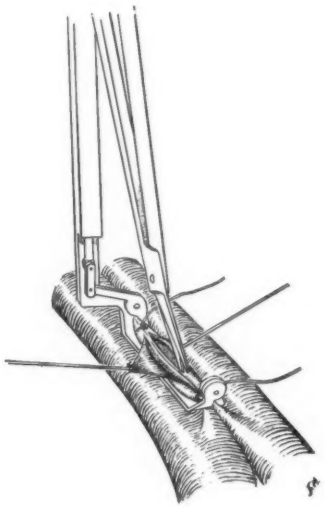

Fig. 4.

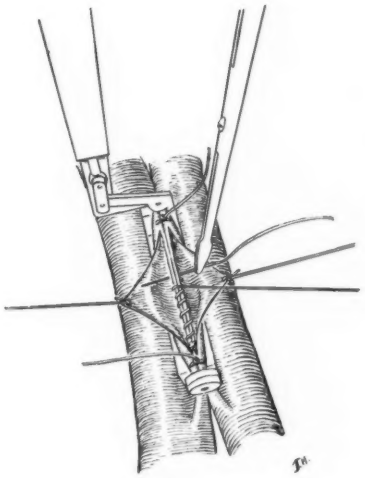

Fig. 5.

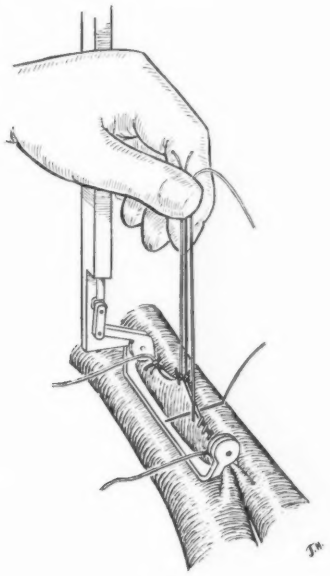

Fig. 6.

tissue, stay sutures[1] are passed through opposite points of both vessels (Fig. 1) at sites which will eventually be the two extremes of the anastomosis; the suture closest to the liver, just distal to the pancreatic vein, is secured first. The distal suture is placed approximately one inch[2] from the first one at a point which is usually just rostral to the first visible branch of the portal vein—the stay sutures are approximately 8 inches long. Next, the open clamp is held vertically with the handle side cephalward, while the stay sutures are passed through its open jaws (Fig. 2). Then, as the clamp is applied to the vessels, traction is made on the stay sutures. The surgeon manipulates the clamp and upper stay suture from the right side, while an assistant retracts the abdominal wall and places traction on the lower stay suture. When the portion of each vessel between the jaws of the clamp is similar and adequate, the clamp is closed until the vessels are held firmly. There should be 1/8 inch to 1/4 inch width of each vessel protruding between the jaws of the clamp for a distance of 1 inch. Once the vessels are secured, the clamp is held in position by the assistant, who exerts gentle traction as required for adequate exposure. Sutures for retraction of the lateral wall of each vessel are next secured to the midportion of each vessel just lateral to its crest (Fig. 3). By means of a fine sharp-pointed knife (e.g., cataract knife) or scissors, each vessel is incised longitudinally just medial to its crest and near its lateral stay suture. The

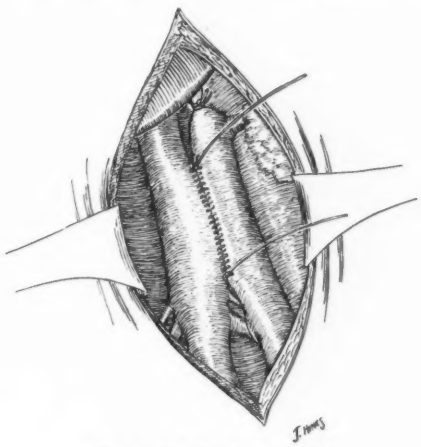

Fig. 7. Eck fistula completed.

[1]Carrel 20 mm. straight arterial needles and No. 5-0 or 6-0 black silk are used for the stay sutures and anastomosis.

[2]For dogs weighing 35 lbs. or more, a larger sized clamp is used which permits the stay sutures to be placed 1¼ inches apart.

incision is enlarged by means of a long-handled pair of scissors to include most of each vessel within the clamp (Fig. 4).

While lateral traction is made on the lateral traction sutures, the medial walls of the two vessels are sewed together by a continuous running suture, which begins at the caudal end of the incision (Fig. 5). The last stitch passes through both walls of each vessel and is thereafter tied to the stay suture at the cephalad end of the clamp.

By a similar suture, the lateral walls of each vessel are sewed together. The first stitch at the lower end passes through both walls of both vessels, but thereafter one is careful to include only the lateral walls in a stitch (Fig. 6). This step is made simple by bringing the two lateral traction sutures together and exerting gentle vertical traction on them and on the suture line that is being laid down. At both extremities the suture is tied to the traction sutures. The clamp is then released, while slight traction is maintained on both traction sutures. If bleeding is excessive, one can reapply the clamp and repair the defect. This is rarely necessary and usually none or only a few cubic centimeters of blood ooze out along the suture line when the clamp is released. Such dissection as may be necessary for ligation of the vena cava or portal vein above the anastomosis should be completed prior to formation of the anastomosis. After ligation is complete, the stay sutures are cut, and the abdomen is closed in layers (Fig. 7).

DISCUSSION

The use of this procedure for portacaval anastomosis minimizes the loss of blood and assures one of a uniform stoma between the vessels. Pressure from the clamp may cause slight injury to the vessel walls, although there has been no postmortem evidence that this is sufficient to cause thrombus formation at the site of anastomosis.

Animals that have been kept for some weeks after the operation have all had widely patent stomas at autopsy. Four animals with Eck fistula prepared by the technique which has been described were fed horse meat exclusively and developed meat intoxication after a few days on the diet.

Animals with the anastomosis prepared by the cutting suture technique may or may not be susceptible to meat intoxication. Failure to develop meat intoxication following Eck fistula formation may be construed as evidence of collateral circulation from the intestines to the liver. This collateral circulation is stimulated by the portal hypertension which results from obstruction of the portal vein in the presence of a stoma that is not sufficiently patent to prevent back pressure. Normally, pressure in the portal vein is greater than that in the vena cava (1). Portacaval anastomosis with portal obstruction not only diverts blood from the liver, but probably reduces the pressure in the portal vein. Hence there is no stimulus to the development of collateral circulation such as occurs in the animal with simple obstruction of the portal vein. A comparison of the effects on liver function of portal obstruction, with and without caval anastomosis, will be presented at a later date.

SUMMARY

A simple, reliable technique is described for the preparation of a portacaval anastomosis in dogs with the aid of a clamp devised especially for that purpose.

REFERENCES

1. Evans, C. A. L. Principles of Human Physiology (Starling). 9th ed., p. 583. Philadelphia: Lee Febiger, 1945.
2. Fishback, F. C. Ann. Surg., 1927, 86: 436–444.
3. Markowitz, J., Yater, W. M., and Burrows, W. H. J. Lab. Clin. M., 1933, 18: 1271–1278.
4. Potts, W. J., Smith, S., and Gibson, S. J. Am. M. Ass., 1946, 132: 627.
5. Whipple, G. H., Robscheit-Robbins, F. S., and Hawkins, W. B. J. Exp. M., 1945, 81: 171–191.

TECHNIQUE OF LOW THIGH AMPUTATION

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THE care of patients with arteriosclerotic ischemic necrosis of the lower extremity still presents many unsolved problems. The correction of altered glucose, fluid, electrolyte, and protein metabolism has promoted to a considerable degree the successful management of these patients. The intensive administration of antibiotic and chemotherapeutic drugs has for the most part eliminated pyogenic infections as a major cause of death. Revitalization of tissue completely necrotic remains impossible and allows recourse to no form of therapy save spontaneous or surgical amputation.

Although some difference of opinion still exists concerning minor details of thigh amputation, there has evolved during the past two decades a general agreement upon the principles of this operation. The combined contributions of McKittrick, Samuels, Callender, Pearl, and others have simplified the technical aspects of low thigh amputation.

There has been a growing conviction that amputation of the lower extremity through the lower third of the thigh is more satisfactory than amputation at either a higher or lower site. It is true that there are definite indications, such as occlusion of the common femoral artery or rapidly advancing anaerobic infection, for performing amputations at a higher level. In the absence of such indications, however, no purpose is served by a high amputation. The difficulty in obtaining viable dermofascial flaps below the patella has for the most part led to abandoning transtibial amputations for arteriosclerosis obliterans.

The practice of subjecting a patient to a lumbar sympathectomy in order that amputation below the patella may be performed has not seemed justified unless there is reason to believe that the amputation can be successfully accomplished through the metatarsal area or distal to this site. There are very few patients with ischemic necrosis of the toes or foot who are candidates for sympathetic interruption of vasomotor tonus. This does not apply to patients who have pain because of arteriosclerotic ischemia. Patients carefully and conservatively selected in this group may be afforded gratifying relief following lumbar sympathectomy. Atlas, de Takats, and Freeman have shown this to be true and our own experiences have confirmed their results.

During the past 2 years, 35 amputations through the lower thigh have been performed for ischemic necrosis at University Hospitals of Cleveland. The neurovascular residents or the author have performed all the operations. The technique to be described has been used in all the procedures. The development of this technique arose from observing amputations performed by many different surgeons. The customary method of low thigh amputation consists of making anterior and posterior dermofascial flaps or a circular incision just above the condyles of the femur. The quadriceps tendon and the medial and lateral musculotendinous bands are cut. The sciatic nerve and popliteal vessels are dissected free and ligated. The femur is transected and closure performed. This technique usually demands alternate internal and external rotation of the thigh. During the course of fashioning the posterior flap and dissecting the popliteal vessels, the extremity is commonly held aloft by an assistant. It is not unusual to observe the surgeon in various awkward positions such as bending far over the operative field or assuming a squatting position while directing his attention to the posterior aspect of the thigh. The ease with which contamination of the sterile field can and does occur during this maneuvering on the part of the surgeon and his assistants is quite apparent.

It should be stated emphatically that operating speed is not to be commended when it is obtained by means of poor hemostasis, rough manipulation of tissues, and increased risk

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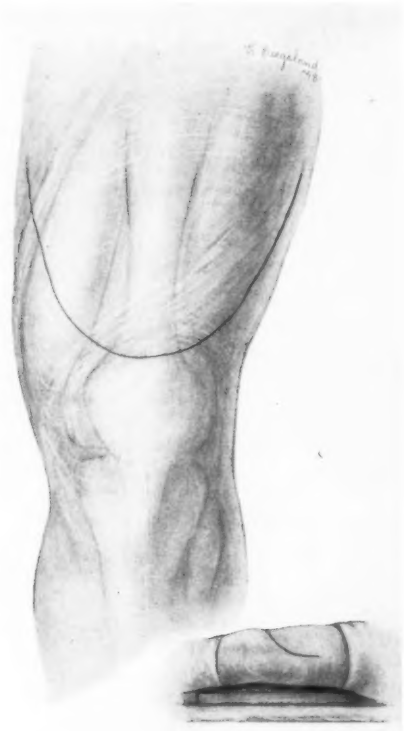

Fig. 1.

Fig. 2.

to the patient. The simplicity of the procedure to be described, however, allows the extremity to be maintained in one position during the entire operation, allows no blunt dissection, minimizes blood loss and shock, and permits completion of the procedure within 10 to 20 minutes. The neurovascular residents who perform all amputations for vascular disease on staff patients, adopt the technique with ease.

OPERATIVE PROCEDURE

Intravenous sodium pentothal, cyclopropane, spinal or refrigeration anesthesia are employed according to indication. Spinal anesthesia is preferred and used in the majority of patients. Refrigeration is used only when the patient is admitted with an acute progressing infection superimposed on arteriosclerotic ischemic necrosis.

The patient is placed flat on his back and the skin of the lower extremity is prepared from upper thigh to midcalf with 70 per cent alcohol and a one to five thousand solution of mercury bichloride. Figure 1 shows the position of the extremity from an anterior and lateral viewpoint. One moist sterile towel is wrapped around the midportion of the thigh and another about the leg just below the knee. Sterile sheets are placed beneath the extremity from the gluteal fold beyond the foot of the operating table. The leg and foot which have been held at an angle of 45 degrees from the table during the preparation are then enclosed in a sterile square table cover and wrapped loosely with sterile gauze. A double sterile sheet is then placed over the upper thighs and lower abdomen so that the lower border approximates the lower border of the sterile towel wrapped about the thigh. The sheet

Fig. 3.

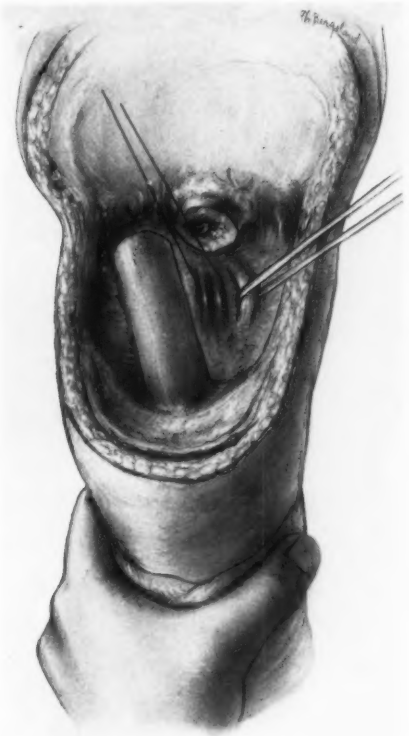

Fig. 4.

is clipped to the towel. The entire field is then covered with a lap sheet after the extremity is inserted through the central opening. This is done in order that the extremity may be removed from the operative field as soon as the amputation has been effected. A sterile block of wood (Figures 1 and 2) 8 by 6 by 1 inches is placed beneath the popliteal space. A tourniquet is never used except in the rare instance that refrigeration anesthesia is employed. The extremity is flat on the table and is never moved during the operation.

A horseshoe shaped incision is made on the anterior surface of the thigh (Fig. 1). The base of the incision lies at the upper border of the patella. The incision includes skin, subcutaneous tissue, and fascia. The great saphenous vein is identified, clamped, and ligated with No. 0 chromic catgut. The quadriceps tendon is incised and the entire dermofascial flap is elevated, in this manner exposing the anterior aspect of the femur (Fig. 2).

A periosteal elevator, Figure 3, is used to remove the periosteum from the anterior and lateral aspects of the femur for a short distance about 5 centimeters above the condyles. A small curved hemostat is inserted behind the femur where the periosteum has been removed. A Gigli saw is drawn through. The saw is represented on Figure 3 by the dotted line at the proximal end of the exposed femur. The femur is then transected by using the saw in a lateral to-and-fro motion. Too much vertical tension will cause the saw to break. The wound is washed with saline during transection of the femur. A hand saw is not used because of the danger of injuring the popliteal vessels.

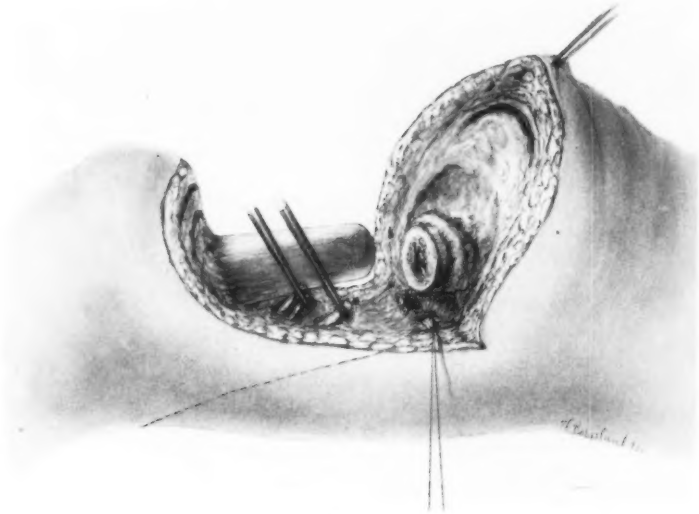

Fig. 5.

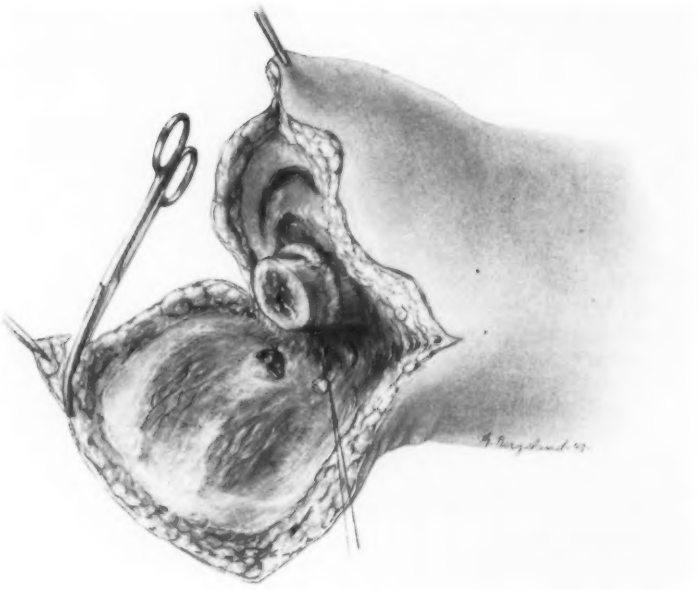

Fig. 6.

The distal end of the femur is angulated medially (Fig. 4). The popliteal vessels are easily visualized, dissected free, clamped, cut, and ligated doubly with No. 0 chromic catgut. The sciatic nerve is also readily identified. If its accompanying small artery is readily visua-

lized, it is ligated separately. Gentle traction on the nerve is made and it is sharply cut with a knife. It then retracts. Neither alcohol nor procaine is injected into the stump of the nerve.

Figure 5 shows a lateral view after the popliteal vessels and the sciatic nerve have been cut. The dotted line in this figure indicates the line of incision for the posterior dermofascial flap. An amputation knife is employed for this incision which starts within the wound at end of femur and continues obliquely outward and downward through the musculotendinous bands of the semimembranosus, semitendinosus, and biceps femoris. The posterior fascia is incised and the incision terminates through the skin at the lower border of the popliteal fossa. The amputated leg is removed from the operative field.

The square corners of the posterior dermofascial flap are then excised, Figure 6. Four or five interrupted sutures of No. 0 chromic catgut are used to approximate the anterior and posterior layers of fascia over the stump of the femur. Interrupted silk sutures approximate the skin in eversion. No drains are used. Dry sterile dressings and a neurological roll are applied. Figure 7 shows a stump on the eighth postoperative day.

Fig. 7.

DISCUSSION

This operation has been performed 35 times during the past 2 years with one postoperative death from uremia on the tenth day following operation. Necrosis of the skin flaps occurred in 1 patient who developed a retrograde thrombosis of the superficial femoral artery extending into the common femoral artery. All of the patients had arteriosclerotic ischemic necrosis and all had superimposed pyogenic infections. All of the operations were performed by the neurovascular residents or the author. Although it is felt that the technical aspects of the procedure contributed beneficially to the welfare of these patients, considerable attention was devoted to the preoperative correction of anemia, dehydration, cardiac decompensation, acidosis, and other complications commonly seen. Penicillin was administered routinely. Postoperative activity was encouraged. The wounds were first dressed on the fifth postoperative day.

Although the technical aspects of this method of thigh amputation were not found in the literature, a complete survey was not possible because of the inaccessibility of some foreign journals.

SUMMARY

A technique of low thigh amputation is presented. The principal advantages are the facility with which the operation is performed, the elimination of awkward maneuvering by the surgeon, the reduction of potential sources of contamination, the minimal amount of blood loss and tissue trauma, and the ease with which patients stand the procedure.

REFERENCES

1. Atlas, L. A. Am. Heart J., 1942, 23: 493.
2. Callender, C. L. J. Am. M. Ass., 1935, 105: 1746.
3. de Takats, G., Fowler, E. F., Jordan, P., and Risley, T. C. J. Am. M. Ass., 1946, 131: 495.
4. Freeman, N., Leeds, F. H., and Gardner, R. E. Ann. Surg., 1947, 126: 873.
5. McKittrick, L. S., and Root, H. F. Diabetic Surgery. Philadelphia: Lea & Febiger, 1928.
6. Pearl, F. Surg. Gyn. Obst., 1941, 73: 381.
7. Samuels, S. S. Ann. Surg., 1940, 112: 105.

BLOOD BANK ORGANIZATION

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DURING the ten year period before the last war physicians began to use progressively increasing amounts of whole blood and plasma in the treatment of patients. This increase was a direct result of better and more popular acquaintance with the value of blood as a therapeutic agent as proved by exhaustive experimental and clinical investigation. The demand soon was so great within hospitals that it became desirable to store these substances in advance of need in order to avoid dangerous and wasteful delays in emergencies and to insure satisfactory and prompt transfusion therapy. A need for improvement in the many technical aspects pertaining to the drawing, storage, preparation, and administration of these substances naturally followed and these were brought to a satisfactory stage of development through the work of a host of independent investigators.

Throughout the period of the war, physicians in both military and civilian practice further observed the value of blood and plasma and popularized its use in shock and hemorrhage, in sepsis and anemia, and in parenteral alimentation for many other diseases. Meanwhile the production, supply, and administration of blood and plasma and its derivatives for patients in the armed services through the co-ordinated efforts of individual investigators, military physicians, universities, the National Research Council, The American National Red Cross, and commercial drug firms, developed with amazing rapidity to the point of satisfactory operation.

In civilian practice comparable strides in the provision of blood and plasma have not been made, either during the war years or in the postwar period. Limitations imposed by the war, chiefly the demands on medical personnel and the necessary restrictions on material, were such that little progress was possible throughout its duration. It is now 3 years after the end of the war and the restrictions no longer exist; yet the problem of blood bank organization adequate to meet the needs of every community is unsolved. In order to contribute to its solution, let us first state clearly the needs, and then examine critically possible methods for their satisfaction. Every hospital in America should have immediately available properly prepared whole blood and plasma in suitable form and in amounts sufficient to meet the needs of practice within that hospital. This is the ideal, but for purposes of practicability minor compromises can and should be made under any organizational plan. Adequate medical care, however, cannot be compromised and it must include blood and plasma service that meets the requirements of the patient, the physician, and the hospital.

The first and most obvious solution to the problem is that of the individual hospital supplying its own blood and plasma. This is done in many hospitals, but there are natural obstacles which stand in the way of a completely adequate service. The chief of these is the difficulty of maintaining without waste a sufficient inventory of blood of the various groups and of plasma reserves to satisfy all requests. This is even more true since attention must now be paid to the Rh factor. For example, only about 1 donor in 350 has blood of group AB Rh negative, 1 in 60 of group B Rh negative, and 1 in 16 of group A Rh negative or O Rh negative. Substitutions may be made in some instances but they are also limited. Other obstacles to a complete service within a single hospital include the depletion of whole blood inventory to provide plasma reserves, the cost of equipment, trained personnel and proper supervision, and space requirements.

In discussing conditions within the individual hospital, it is not meant to imply that hospitals in general cannot manage most of their own blood transfusion obligations sim-

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ply, effectively, and economically. Those hospitals large enough to maintain a pathologist, a clinical pathologic laboratory, and a resident house staff are equipped with the necessary personnel. In almost all hospitals the clinical pathologist is a physician of high intellect, well versed in the theoretical and practical phases of safe blood transfusion. Improved apparatus which facilitate the transfusion of blood properly preserved in closed pyrogen-free containers are available at low cost from commercial houses, as are grouping and anti-Rh testing serums of excellent titer and specificity. In most instances in which blood transfusion is desired the proper donor may be found among friends of the patient without undue delay and reserves of blood are not needed. In the larger hospitals (those of 300 or more beds), small blood bank organizations can properly be operated further to fulfill blood transfusion obligations. These functions are ably performed by the hospitals and their staffs and they should continue to maintain self-reliance by participating to the limit of their respective abilities.

Since the ability to meet the circumstances naturally varies greatly with individual hospitals, it follows logically that blood bank organization within a community should be devised to supplement the hospital service in accord with the particular needs. For example, one hospital may care to use the central organization only when friends of the patients cannot be located or when available donors or reserves of blood are not of the compatible blood group, or when an emergency exists which does not permit waiting for laboratory search. A smaller hospital, lacking personnel, may find it more suitable to rely upon the organization as a source for all blood used. In the relatively few instances in which plasma is more desirable than whole blood, all hospitals except those large ones properly equipped to prepare their own plasma would rely upon the central organization.

The problem as it exists within the individual hospitals has been reviewed in order to fix the amount of help required to make complete a blood transfusion service for any given community. This step is necessary if the problem is to be approached intelligently and conflict with existing functions within the hospital avoided. Nine years ago in the greater Cincinnati area a community blood and plasma transfusion center was organized according to this concept. It has met with considerable success. At this point it seems desirable to trace its growth, describe how it operates, and refer to some of its accomplishments.

The project was designed in the Department of Surgery at the University of Cincinnati and the Cincinnati General Hospital and has been in operation since December 10, 1938. Its pioneer development was sponsored by the Cincinnati and Hamilton County Chapter of the American Red Cross, though it was without precedent for a local chapter of the American Red Cross to collaborate with a university in order to produce such an organization. In the first few years of operation the blood bank was used largely for the benefit of patients in the Cincinnati General Hospital, all of whom are on a free medical service basis. A nominal charge was made to the occasional private hospital patient requiring bank blood. As this phase of the service expanded, the Red Cross felt that it was being put in the position of selling blood, which was in conflict with its policy. At the same time the service had become self-supporting and transfer of sponsorship could be made without requiring a subsidy. On January 1, 1944, at the request of the Red Cross, sponsorship was transferred to the University of Cincinnati and the project is now known as the University Blood Transfusion Service. It operates for the Cincinnati General Hospital and for 15 hospitals in the metropolitan area.

The office and laboratory facilities and details of the methods, technique, and equipment used in the drawing of blood and in the preparation and processing of plasma have been described elsewhere (1, 2, 3, 4, 5, 6). The service is directed by a member of the attending staff of the Department of Surgery. A secretary, 6 laboratory technicians, a graduate nurse, and a diener are employed and a number of part-time volunteers, some of whom are Red Cross nurses aides, serve at regularly scheduled hours.

The service provides whole blood, plasma in the liquid, frozen, and dry states, and red

blood cells in dextrose solution. Plasma production has been suspended since the Army and Navy surplus was made available, but will be resumed when this supply is exhausted. Ordinarily all hospitals participating in the service are given a supply of plasma for use in emergencies. Whole blood is dispensed only at the request of a physician for a specified patient. Whenever a unit of whole blood or plasma is issued the information needed by the service is entered on a printed form which records the amount of whole blood or plasma desired, the name of the patient, the method of repayment if it has been decided upon, the signature of the physician, and the signature and address of the responsible relative or friend. Neither the physician nor the hospital assumes any responsibility for seeing that repayment is made. The physician is asked merely to explain the obligation to the patient or his relative at the time the slip is signed and the hospital simply to see that the service receives the forms properly filled out.

Much of the success of this project is due to the fact that repayment of the obligation to the service is made according to the circumstances of the patient and his family. These circumstances are indicated on the request forms by the physician. Most patients fall into one of four classifications. If the patient is financially able and has willing blood donors, the charge is $12.50 and one donor for each unit of blood (500 c.c.) or plasma (250 c.c.); if he is financially able and has no willing donors the charge is $25.00; if he has willing donors but is poor, two suitable donors are accepted for each unit used; if the patient is indigent and has no friends willing and able to serve as donors, the blood or plasma is supplied without obligation, out of reserves obtained from those repaying with two donors. Red blood cell suspensions are a by-product of plasma preparation and are charged for at one-half these rates. All classifications are flexible and obligations are always adjusted to meet the circumstances. For example, if the patient who is neither indigent nor well-to-do has received many units of blood or plasma and has been subjected to the expense of protracted hospital and medical care, any part of the accrued obligation, either in blood donors or in money is acceptable as payment in full. A statement by the patient's doctor as to the limit of the ability to pay is accepted as final. In any event no method of collection other than a simple statement of obligation is ever used. At no time during the 9 years of operation of this service has a request for blood or plasma been refused, the reserves have never been exhausted, and no blood has been purchased from donors by the service.

Donors present themselves at central headquarters during 3 regularly scheduled half day periods each week. At these times a physician is present to draw the blood. He is paid by the participating hospitals, the share of each being prorated according to the number of transactions during the preceding month. In 1946 this amounted to about 20 cents for each transaction. There is no other charge made to hospitals by the service.

In a few respects the operation of the service for patients in the Cincinnati General Hospital differs from that for patients in other hospitals. Since patients in the General Hospital are on a free medical service basis, all repayment is made with blood donors on a unit for unit basis and no cash payments are ever received from patients. In return the General Hospital provides the service with space, heat, light, laundry, and some chemicals.

The usefulness of this service to the community is indicated by its growth, expressed in terms of the number of transactions in units of whole blood and plasma. During the years of operation there has been a progressive increase from 2,687 units for the year 1939 to 8,025 units for the year 1945. This dropped to 7,152 units in the year 1946 because of the use of free government plasma to supply part of the demand. From 1943 to 1946 inclusive, 15,148 units of whole blood and plasma were issued to the General Hospital and 13,136 units were issued to other participating hospitals, making a total of 28,284 units of whole blood and plasma for the 4 year period.

The financial operation of the service has been satisfactory. Expenditures consist of salaries for secretarial and technical personnel, supplies for the office and laboratory, including grouping serum and all items used in donor sets, and maintenance in the general

headquarters and on refrigeration and laboratory equipment. There is no salaried medical direction. The income to the service is derived entirely from patients who are paying for private hospital and medical care and who have received blood or plasma from the service. The total expenditure for the 4 year period from 1943 to 1946 inclusive was $54,107.18. The total income during this same period was $87,060.59, leaving a surplus of $32,953.41, despite the fact that more than half the transactions involved patients making repayment with donors only. This surplus is to be used in the purchase of new equipment for the blood transfusion service when the building program permits new headquarters. Since in the 4 year period from 1943 to 1946 inclusive there were 28,284 transactions in whole blood and plasma and $87,060.59 in income, each transaction cost the service about $3.00. This cost was paid by the patients who received the benefits at the rate of not more than $25.00 or $12.50 and one donor for each unit. In no instance has attempt at collection been more than a simple statement of obligation to the patient, and blood and plasma in any amount requested have always been issued regardless of the financial circumstances of the patient.

A description of this service has been made in order to illustrate how the blood transfusion problem has been managed in a single community. It has been moderately successful in its accomplishments but they fall short of being ideal. A careful check reveals that only about 95 per cent of the requests are satisfied promptly. In the remaining 5 per cent there is delay in supplying Rh negative blood of a specified group or blood of group AB and B. A second defect in the service is that no provision is made to serve hospitals in outlying smaller cities and towns. It would not be difficult to extend the service to include these localities by altering the organizational plan. Such an extension would at the same time mitigate the problem of shortages of the rarer groups of blood because of increased inventories that would result.

The service which has just been described obviously will not suit exactly all communities, but if it were applied to others throughout the country, the plan could and should be made as flexible as necessary to meet the requirements of each. The variables to be met would be the number and sizes of the participating hospitals and the distances between them. For example, by the adoption of standard apparatus and techniques for the drawing of blood, hospitals at greater distances might make periodic collections of blood from friends and relatives of patients and transport them to the center in return for a supply of plasma and blood of more useful distribution in relation to the blood groups. Hospitals close to the center might prefer to have the blood collected there and to draw out both whole blood and plasma according to need. The size of the hospital and the degree to which it has developed its own transfusion service would also determine the extent of its reliance upon the center. Schemes of operation would have to vary in order to suit both community and hospital requirements but they would resemble one another in their fundamental objectives. This phase of the problem, that of working out details of the plan in a particular community, should not prove to be difficult.

In order to develop and put into effect similar blood bank organizations operating from within strategically located cities and have them serve the entire country, the impetus must come from an organization capable of dealing with the problems on a nationwide scale. Authority should then be delegated to agents within state or other regional units to co-ordinate the activities in each. The interests of the community would best be served if these agents were physicians associated with medical centers, who would then be in a position to understand the problems within the hospitals as well as within the community. These men should be carefully selected for their interest in and knowledge of the theoretical and practical aspects of blood transfusion and for their administrative ability.

SUMMARY

The plan of blood bank organization now in operation in the Cincinnati area has worked effectively and economically for almost 9 years. It could be adopted on a nationwide basis, adjusted to suit every community and yet retain its fundamental principles, not the

least of which is the preservation of individual responsibility. The patient would receive blood and plasma in the amount needed regardless of his financial circumstances. If payment in money could not be made, he still would be allowed to participate by supplying blood donors from his friends and relatives. If he had no willing donors, he would not be denied the service. There would be no restrictions placed on the physician either by the amounts of blood or plasma readily available or by the financial ability of his patient.

In the majority of blood transfusion procedures there is enough time and sufficient personnel and facilities within the hospital to secure suitable donors among friends of the patient and to draw and administer the blood. Under a community plan as described the hospital would continue to be self-reliant to the limits of its ability, but deficiencies in its service would be complemented.

The service would be paid for by those who receive the benefits without excessive cost to the individual and without the need for a protracted annual subsidy from any source. Because the service would be self-supporting, it could not become a financial burden to the community.

A plan to provide blood without charge to all and to finance the project by the use of a subsidy, however derived, would be ill-advised. This is the most extravagant method of establishing an essential service. There is no such thing as blood without costs. Any transfusion service, whether locally or nationally organized, requires the employment of skilled personnel trained for highly technical jobs. Their services will cost money. These costs, if not paid by the person who receives blood, must be paid by others. Thus to speak of transfusion service without charge is merely to indulge in double-talk. Such a scheme would discourage the fulfillment of personal obligations and invite charity where it is not needed. It would also, by "creating among the masses an appetite for gifts and the habit of receiving them," build up a mountainous service, much of which is not needed because it is already being supplied effectively within individual hospitals. Any organizational plan devised to supplant existing hospital services would become vastly more expensive than one which afforded only the help necessary to make them complete.

Adequate blood transfusion service for every patient is important enough to justify the use of a subsidy if it cannot be avoided. One way of solving the transfusion problem in communities might be the sponsorship of a national program by a scientific organization willing to make an initial subsidy and then turn over control as the local organizations become self-supporting. It is essential to consider methods which preserve the fundamental principles of self-reliance and individual responsibility.

REFERENCES

1. Hoxworth, Paul I. Arch. Surg., 1941, 42: 321-337, 480-497, 498-507.
2. Idem. Surgery, 1944, 15: 832-888.
3. Hoxworth, Paul I., and Ames, Azel. J. Am. M. Ass., 1937, 108: 1234-1236.
4. Hoxworth, Paul I., and Block, Gordon. South. M. J., 1944, 37: 96-99.
5. Strumia, Max, and McGraw, J. J. Am. J. Clin. Path., 1941, 11: 228-306.
6. Strumia, Max, McGraw, J. J., and Reichel, John. Am. J. Clin. Path., 1941, 11: 175-194, 388-401, 480-496.

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VAGOTOMY AND THE MANN-WILLIAMSON ULCER

THE discovery by Mann and Williamson[1] of a method which regularly leads to the production of progressive peptic ulcers in experimental animals has proved to be of great importance in the study of the pathogenesis of these lesions. It has also made possible an evaluation of various therapeutic procedures both as prophylactic and as curative measures under the controlled conditions of the laboratory. It seems probable that the explanation proposed for the cause of these ulcers is correct, namely that they are due to the corrosive effect of the acid gastric content on the jejunal mucosa when deprived of the continuous neutralizing effect of the alkaline duodenal secretions. In this connection, however, certain observations made by the present writer are of interest and not easily explained.

Thus, when the pancreatic juice in dogs is diverted to the exterior by a fistula of the type which has been described by Dragstedt, Montgomery, and Ellis[2], progressive ulcers appear in the duodenum in almost every case and are exceedingly difficult to prevent. Total pancreatectomy, however, which also excludes pancreatic juice from the duodenum, is almost never followed by ulceration. In over 500 of these operations in our laboratory, the incidence of ulcer is less than five per cent. We have not been able to demonstrate that pancreatectomy decreases gastric secretion, so the failure of these animals to develop ulcers remains unexplained.

Although the effect of complete vagotomy on the development of experimental Mann-Williamson ulcers was not investigated before this operation was introduced[3] for the treatment of intractable peptic ulcer in man, it has subsequently been studied in our laboratory and simultaneously by several other investigators [4,5,6,7]. It seems clear that vagotomy has little or no beneficial effect on the occurrence or course of these ulcers. This is in striking contrast to the effect of complete vagotomy in gastrojejunal ulcer in man. Here the ulcers heal[8] and have remained healed for periods of three to five years. The opinion of almost all surgeons is apparently unanimous that vagotomy is a satisfactory treatment for gastrojejunal ulcer following the performance of either gastroenterostomy or gastric resection in man.

[1]Mann, F. C., and Williamson, C. S. Ann. Surg., 1923, 77: 409.

[2]Dragstedt, L. R., Montgomery, M. L., and Ellis, J. C. Proc. Soc. Exp. Biol., N. Y., 1930, 28: 109.

[3]Dragstedt, L. R., and Owens, F. M., Jr. Proc. Soc. Exp. Biol., N. Y., 1943, 53: 152.

[4]Enerson, D. M., Woodward, E. R., Tovee, E. B., Neal, W. B., Sibley, J. A., and Dragstedt, L. R. Arch. Surg. (in press).

[5]Harkins, H. N., and Hooker, D. H. Surgery, 1947, 22: 244.

[6]Saltzstein, H. C., Sandweiss, D. J., Hammer, J. M., Hill, E. J., and Vandenberg, H. J. Arch. Surg., 1947, 55: 130.

[7]Oliver, J. V. Arch. Surg., 1947, 55: 180.

[8]Dragstedt, L. R., Clarke, J. S., Harper, P. V., Jr., Woodward, E. R., and Tovee, E. B. J. Thorac. Surg., 1947, 16: 226.

What is the explanation for this marked difference in response to vagotomy displayed by the experimental as compared with the clinical ulcer? Is the Mann-Williamson ulcer in dogs strictly comparable to the stoma ulcer seen in man? These are important practical as well as theoretical questions.

One obvious difference between the two lesions depends upon the fact that in the experimental ulcer the duodenal secretions are deviated completely into the lower intestine, while in most stoma ulcers in man these secretions pass over the ulcer area. An exception to this latter statement is the stoma ulcer that develops when a Roux or Y type of gastroenterostomy is performed. Exalto[9] many years ago called attention to the high incidence of stoma ulcers with this type of anastomosis, both when done for duodenal ulcer in man or when constructed in normal dogs. It is quite likely that the pathogenesis of these experimental ulcers of Exalto is similar to that of the Mann-Williamson lesion. The Y type of gastroenterostomy has now been abandoned for the treatment of duodenal ulcer, but occasionally stoma ulcers are encountered in man when the situation resembles that in the experimental ulcers of Exalto and of Mann and Williamson.

Two cases of this type have been recently encountered in our clinic and are of interest in that a complete vagotomy failed to prevent their occurrence or permit them to heal. In both cases, vagotomy plus gastroenterostomy was performed for intractable duodenal ulcer with pyloric stenosis. Because of subsequent obstruction to the proximal loop at the site of anastomosis, an entero-entero anastomosis was made between the proximal and distal loops of jejunum. This had the effect of diverting the duodenal juices from the region of the anastomosis and creating a situation resembling that in the Mann-Williamson ulcer. Progressive stoma ulcers appeared in the jejunum adjacent to the anastomosis in spite of the fact that physiological studies indicated that the vagotomy had been complete. Since these are the only stoma ulcers encountered in a series of 168 complete vagotomies with gastroenterostomy, the adverse effect of sidetracking the duodenal secretions from the region of the anastomosis becomes more impressive. It is likewise important to emphasize that we now have evidence both from the laboratory and the clinic that vagotomy will not prevent or cure stoma ulcers that arise under the conditions which have been mentioned.

Considerations such as these make one question the advisability of using the Mann-Williamson preparation as a test object for the efficacy of therapeutic measures proposed for peptic ulcers in man. It is probable on the basis of recent findings that most duodenal and stoma ulcers are due to gastric hypersecretion and that complete absence of the automatic neutralizing effect of the duodenal secretions plays the predominant role in only a few special situations such as those here discussed. Gastroenterostomy is not followed by stoma ulcer unless gastric hypersecretion exists or is experimentally produced or unless the duodenal secretions are diverted from the area of anastomosis. It is for this reason that jejunal ulcers do not occur after gastroenterostomy in normal dogs or in man with carcinoma of the stomach or gastric ulcer associated with normal or depressed secretion. When the excessive gastric secretion characteristic of patients who have duodenal ulcer is returned to normal values by complete vagotomy, stoma ulcers do not take place unless the duodenal secretions are diverted from the region of the anastomosis.

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[9]Exalto, J. Mitt. Grenzgeb. Med. Chir., 1911, 23: 13.

THE PRESENT STATUS OF PULMONARY RESECTION IN THE TREATMENT OF PULMONARY TUBERCULOSIS

SINCE Brauer and Frederich reported the performance of a successful thoracoplasty more than forty years ago, thoracic surgeons throughout the world have been increasingly interested in the surgical treatment of pulmonary tuberculosis. Many new collapse procedures, some good and some bad, have been devised and all the acceptable ones have been tested for their therapeutic value. The indications for each have been crystallized and clarified so that we know with reasonable assurance what to expect. While several procedures have been effective, there still remains a limited group of patients who are in need of more adequate measures to eliminate tubercle bacilli from the sputum. Under such circumstances it is not strange that pulmonary resection should finally come under careful consideration. During the past ten years resection has been given a trial in an increasing number of patients. The results have been rather unsatisfactory. The technique used in earlier resections necessitated cutting through tuberculous tissue in dividing the hilar structures, a step which resulted in many serious complications and often in death. Later, with refinements in technique, which included the individual ligation of the hilar vessels, and with a more careful and painstaking handling of the bronchus, results have been improved.

In 1942, 46 cases of lobectomy were reported with a mortality of 25 per cent, and 29 cases of pneumonectomy with a mortality of 45 per cent. The satisfactory results were tabulated as 68 per cent for lobectomy and 41 per cent for pneumonectomy. These cases were particularly interesting because in many of them a diagnosis of tumor or of some other nontuberculous lesion had been made; however, following operation, the condition was found to be tuberculosis. The indications for operation were varied; among them were tuberculoma, tuberculous bronchiectasis, bronchial stenosis, and postthoracoplasty cavity. Complications were common and included fistula, contralateral spread, empyema, etc. The best results were reported in that group of patients whose sputum was found to be negative for tubercle bacilli previous to resection.

One might expect the poor results obtained in the early group of cases to act as a deterrent to any enthusiasm which might arise in favor of the procedure. This is not true, however, for since 1944 an increasing number of patients have had pulmonary resection performed to relieve a variety of conditions. A sufficient length of time has not yet elapsed to determine what the final results will be. Up to the present, the indications for resection have been flexible and have varied widely throughout the country. Certain facts must be kept in mind if pulmonary resection is to rest in the niche occupied by approved methods of treatment. Tuberculosis is not localized in one structure of the body; distant foci may lie dormant for long periods, a fact which may permit a false sense of security both to the physician and his patient. Later, through deleterious influences and alterations in physiology, these foci may become active and the disease become more formidable than before. Such relapses are typical of tuberculosis and may have no connection with any form of previous therapy. It is important that each patient who is considered for surgical treatment should be carefully studied and that all the possibilities be weighed by a team consisting of at least an internist and a surgeon with sufficient experience and knowledge of the vagaries of the disease to permit a logical choice of procedure.

Pulmonary resection, whether lobectomy or pneumonectomy, is a major operation regardless of the pathology present. The loss of respiratory function must be seriously considered both as to its immediate and late effects, The useless sacrifice of normal functioning pulmonary tissue may be ill advised. This statement is borne out by the latest reported results in approximately 400 cases of resection: in less than 50 per cent the sputum was negative on culture, in over 30 per cent it was positive, and 25 per cent of the patients are dead.

While the indications for resection still vary, probably the most outstanding and universally acceptable are: (1) Failure of the thoracoplasty. Failure necessarily implies an adequate thoracoplasty which has failed to close a cavity, with a resulting bronchiectasis and with the sputum positive for tubercle bacilli. Resection is indicated in such cases when the opposite lung or remaining lobes are free from disease or show only quiescent minimal lesions. (2) Bronchial stenosis which represents a burned out lesion with cicatricial contracture of such a high degree that it interferes with drainage and leads to frequent bouts of recurrent pneumonitis, atelectasis, lung abscess, and toxemia. The stenosis may be in a stem or lobar bronchus. (3) Tuberculoma, not infrequently located near the hilum and causing bronchial obstruction, cannot always be differentiated from carcinoma. Delay in such cases may, in certain instances, invite disaster. (4) Failure of a pneumothorax. Adequate collapse is obtained which is equal to or superior to what might be expected from thoracoplasty, but the underlying cavities remain open and the sputum positive. Other indications less clear include: (5) Giant cavities. Some prefer in such cases a trial of collapse therapy before extirpation, while others carry out resection on the premise that collapse measures will be unsatisfactory. Collapse therapy is to be preferred if a reasonable chance of success seems likely. (6) Basal lesions which should be treated by means of some type of collapse therapy in the form of artificial pneumothorax, phrenicotomy, or pneumoperitoneum, and should be given preference of trial. (7) Hilar, lower lobe apical, and middle lobe cavities are not readily amenable to thoracoplasty, but other minor collapse procedures merit careful consideration.

The most common and serious complications and sequelae after resection are: (1) Reactivation or spread of the tuberculous process in the remaining pulmonary tissue, ipsolateral or contralateral. The complete elimination of spread or reactivation is impossible but a more careful and thorough study of the tuberculous process will certainly reduce the frequency of its occurrence. Following lobectomy the forced overexpansion of the remaining lobe or lobes, which undoubtedly contain unrecognized healed and unhealed lesions, is dangerous. Thoracoplasty performed either at the time of, or at an early date following, resection will accomplish three important things: it will obliterate the pleural space left after the resection, it will prevent the overdistention of the remaining lobe, and it will at the same time permit normal function of the lobe. (2) Mixed infection or tuberculous empyema. Early obliteration of the dead space by thoracoplasty and phrenicotomy following pneumonectomy reduces the duration of disturbed respiratory function, lessens mediastinal shift with overexpansion of the remaining lung, and reduces the chances of infection, early and late. We have no assurance that a longstanding dead space following pneumonectomy for tuberculosis will react any differently than that in those cases of extrapleural pneumothorax or oleothorax in which a tuberculous extrapleural empyema has occurred in 50 per cent of the cases as long as five years

later. (3) Bronchial fistula. When a bronchial fistula connects with a large dead space, early infection follows. Such fistulas are most common in cases in which acute tuberculous bronchitis exists at the time of surgery. Until the disease in the bronchus is brought under control, operation should be delayed and other procedures should be used to treat the acute process. This precaution will also reduce the ulceration which is encountered in the bronchial stump and which has been found to contribute to the persistence of tubercle bacilli in the sputum.

Streptomycin has proved to be valuable in the treatment of tuberculosis and should be tried before surgery is instituted, particularly if a tuberculous bronchiectasis existed before or continues after thoracoplasty. The drug has given excellent results in acute tuberculous bronchitis. It has also been valuable in controlling, and perhaps preventing, acute tuberculous empyema following resection. Streptomycin can be introduced directly into the pleural cavity previous to obliteration by thoracoplasty. Streptomycin gives promise of controlling, for a time at least, early postoperative spreads.

Resection in pulmonary tuberculosis is not the final answer. It is a dangerous operation and decision to use it must be made only after other recognized collapse procedures have been carefully considered and found wanting. To ignore this warning will bring disrepute to a therapeutic measure which has its place in the treatment of pulmonary tuberculosis. The value of resection can be determined only by the results obtained over a long period of time.

JOSEPH W. GALE.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE second edition and revision of *Normal Encephalogram*[1] by Davidoff and Dyke was undertaken alone by Dr. L. M. Davidoff due to the tragic and untimely death of Cornelius C. Dyke on April 23, 1943. This very worthwhile book first appeared in 1937 and was written in response to numerous requests from neurological surgeons, neurologists, roentgenologists, pediatricians, and internists. In the fields of all these specialists, encephalography is utilized and basic knowledge of the appearance of the normal encephalogram is essential in order to make correct interpretations of the roentgenograms after the injection of gas.

The object of the book is to present a fundamental thesis on encephalography based not only on the author's experience with many thousands of encephalograms but also a review of the literature on this subject. As stated in the preface to the first edition, "The body of the book is concerned with what might be termed encephalographic anatomy. By this we mean the anatomy of the living brain and its coverings viewed by means of the contrasting shadows of tissues and gas in the stereoscopic roentgenogram."

The various chapter headings and contents in the second edition are essentially unchanged from the first edition. There are, however, numerous additions and there is a very worthwhile review of all new contributions on encephalography appearing in the recent literature.

Anyone interested in any phase of encephalography will find this volume most valuable.

HOWARD N. LANDER.

WHEN one contemplates the treatment of a patient who has a surgical disease, it is amazing to find how much more is necessary to treat the patient properly than simply knowing the anatomic diagnosis and having the ability to perform a standard operative procedure. Allusion may be made to just a few items such as hydration, the nutritional status including vitamin balance, blood picture, electrolytes, blood chloride and protein levels, and nitrogen retention. Moreover complicating anatomic disorders must be detected, controlled, or corrected if possible before surgery is attempted. Among these may be mentioned oral sepsis, diabetes, chronic nephritis, coronary disease, prostatic hypertrophy, and abnormal mental states.

It is desirable to alter, at least to a degree, the methods of teaching of surgery. Too often procedures and precepts are presented and advocated without giving the reason or philosophy for such. The proper management of a disease in its various stages and in different types of individuals that may have anatomic complications or abnormal physiologic states can be carried out only by one possessing much basic information and the ability to utilize such information to build a correct therapeutic structure. Trusting to memory alone is not sufficient because any surgeon will soon encounter a condition that he has not been specifically instructed about; moreover without reasoning, experience less likely will develop his mental stature. Therefore correct teaching necessitates supplying a foundation on which by guidance in thinking and reasoning an accurate mental structure can be erected.

With these points in mind the recent work by Bancroft and Wade has been surveyed rather critically and it is gratifying to state that in general these requirements have been fulfilled. This work *Surgical Treatment of the Abdomen*[2] first appeared in 1941 under the title of *Operative Surgery* and was to be one of several volumes to be published by another publishing house. The plan did not materialize and in time the present publishers arranged for the complete set. Four volumes covering various phases of surgery have appeared; two on surgical treatment of the motor skeletal system, one on surgical treatment of the nervous system and one on surgical treatment of the soft tissues. The present volume which is a complete revision of the original edition is the fifth of the series.

The title of *Surgical Treatment of the Abdomen* belies the scope of this work since there is a section of 145 pages on anesthesia, one of 142 pages on the principles of surgical technique and one of 101 pages on surgery of the mouth including the salivary glands and the esophagus. This is not offered as a criticism of the work but of the title. In fact, the chapters on anesthesia are so comprehensive and lucid that any surgeon would do well to read them. At the operating table just one person is responsible and that is the surgeon. He should know the principles of anesthesia and the facts about any or all that are afforded him. An interesting detail described is the relationship between preoperative sedation and anesthetic used. The pharmacological actions of each agent are described again giving the why for the decisions.

[1] THE NORMAL ENCEPHALOGRAM. By Leo M. Davidoff, M.D., and Cornelius G. Dyke, M.D. 2d rev. ed. Philadelphia: Lea & Febiger, 1946.

[2] SURGICAL TREATMENT OF THE ABDOMEN. By Frederic W. Bancroft, A.B., M.D., F.A.C.S., and Preston A. Wade, A.B., M.D., F.A.C.S. Philadelphia, London, Montreal: J. B. Lippincott Co., 1948.

A similar attitude can be taken on preoperative and postoperative treatment. This is well illustrated n a discussion of diabetes in the surgical patient. The problem is carefully analyzed, a solution arrived at by common sense reasoning and presented in a concise manner requiring only a few minutes to read. The chapter on the fundamental principles of surgical technique written by the late Mont Reid and Stevenson deserves special attention. Here is described the correct ritual of the operating room. The attention to almost countless details, many minor in appearance, which is so essential to a safe, prompt, and successful conclusion is described in full. One cannot but agree with the senior author when he states in the preface "It really should be read by every surgeon, by every resident and by every intern." To this may be added—"and adhered to."

Section four is devoted to surgery of the abdomen. The material is presented in a lucid and pleasing manner. Special attention may be drawn to the chapter on peritonitis and peritoneal abscesses by Coller and Ransom. The authors stress the reasons for their conclusions and advice. Chapter 15 on the surgical therapy of lesions of the stomach and duodenum was written by the late Roscoe R. Graham. Much informative material is presented which should guide the surgeon in the line of proper approach to the specific lesion to be treated. His discussion of the ulcer-cancer problem as related to the stomach is concise and definite and should be accepted. Stone in his chapter on the anus clearly demonstrates how a subject that is so frequently neglected and uninteresting to so many surgeons can be made not only interesting and informative but a pleasure to read. Ravdin in his chapter on diseases of the liver gives a concise description of this complicated problem as it is encountered today. His conclusions are founded upon sound scientific reasoning based upon research in this field and close observation on the human subject. The addendum to this chapter on portacaval anastomosis for the relief of portal hypertension by Blakemore is timely and most interesting.

Aside from the portions specifically mentioned this work of 1,026 pages contains chapters on abdominal incisions by Gurd, the significance of gastroscopy for the surgeon by Schindler, gastrojejunal ulcer by Pfieffer, surgery of the small intestine by Allen and Welch, appendicitis, its surgical treatment by Ochsner, the colon and rectum by Rankin and Graham, surgery of the biliary tract by Whipple, diseases of the pancreas by Parsons, surgery of the spleen by Rives and Maes, and physiologic aspects of postoperative care by Bassler. The material is well arranged. It is enriched by 457 illustrations and 3 colored plates, all of excellent quality. Such a large field is difficult to cover completely so that material is in a sequential order and unnecessary repetition is eliminated. The editor has accomplished this in a very commendable manner. The impression gleaned from the work is that in many ways it is a leader in a type of presentation that stresses not only what to do but why.

The chapters by Reid, Graham, and Gurd cannot be read without becoming acutely aware of the stupendous loss the profession has sustained in the passing of these great surgeons, scholars, scientists, and courteous gentlemen. JOHN A. WOLFER.

THE textbook *Lehrbuch der Gynaekologie*[1] is the first volume of a three volume series of texts covering the field of gynecology and obstetrics. It has been developed since the war in order to fill the gap which was a result of the apparent loss of much of the textbook material, especially for the practitioner and student. Professor Guggisberg, director of The University Women's Clinic at Bern, has compiled the text and is the author of seven chapters. Professors Hintzsche, F. Ludwig, C. Muller, and Neuweiler contribute the remaining twenty-one chapters.

In this large volume a tremendous amount of material is presented in an orderly, but rather uninteresting fashion. One is immediately aware of the complete absence of any bibliography and the scarcity of any reference to individual work. From the student's standpoint, this would be a rather prominent deficiency, in that more extensive study of a specific subject would be impossible with this text as a basis. An extenuating circumstance in regard to this deficit may be the lack of reference material in Germany at the present time. Another rather noticeable omission is that of the detail of operative technique and operative therapy. In general this lack is of little moment to the student or practitioner. However, the more common procedures of hysterectomy and repair should be included.

The caliber of the illustrations in this volume varies considerably. The color photographs are little short of remarkable in detail and subject material. The most striking examples of this art are to be found in the chapters on diseases of the vulva and vagina, carcinoma of the cervix, and myoma. These would be outstanding in any book. On the other hand, many of the black and white and line drawings are indistinct and too diagrammatic to be of much value. The photomicrographs are in general rather poor, although those which were taken of the early malignant changes in the cervix are well done.

The arrangement of chapters in the first half of the volume follows the usual lines. Anatomy, embryology, and congenital malformations are covered adequately. The drawings are poor but hysterograms are good. Constitutional and growth disturbances, physiology, and functional disturbances are discussed most completely by Guggisberg. The chapter covering the abnormalities of menstrual flow, disturbances of secretion, and pain is extremely well done. Here again, however is a photomicrograph of "glandular cystic hyperplasia of the endometrium," which to all the world looks like an advanced secretory endometrium. The pathogenesis of the organic and

[1] LEHRBUCH DER GYNAEKOLOGIE. By Prof. Dr. Hans Guggisberg. Basel: S. Karger, 1946.

functional disturbances and diagnostic procedures conclude the chapters on general topics.

Muller's material on diseases of the vulva and vagina and Neuweiler's on diseases of the uterus are certainly to me the best in the text, and of this group the discussion of myomas with therapy is outstanding. Here also are to be found the beautiful color photographs which add much to the value of the work. Interesting to note here is the use of intracervical and intrauterine sclerosing solutions as part of the treatment of abnormal uterine bleeding. Also the mortality figures on the Wertheim procedure are those of past years. Meigs, his coworkers, and others have improved materially on the 15 per cent quoted by Neuweiler.

Diseases and tumors of the ovary are covered briefly. Incidence of malignancy is missing in cases of special tumors. The classification is as good as the majority of classifications of ovarian tumors. Diagnostic points are well taken. Discussion of diseases of the tubes is quite brief. Tubal pregnancy is not included here, and is only mentioned in several other chapters. Possibly it is covered in another volume.

Infections of the genitalia, malpositions of the uterus, and endometriosis are separated from other discussions of diseases of the genitalia by chapters on extragenital lesions associated with gynecological disease. Diseases of the pelvic connective tissue, abdominal wall, and intestinal tract are mentioned briefly. A 60 page chapter on diseases of the urinary tract attempts to cover urology with the result that many of the subjects of major importance to the gynecologist are dismissed with but a few words.

There is a short discussion of internal and external endometriosis with only a few inadequate lines on therapy. Sterility is covered well with extremely clear hysterosalpingograms and a good dissertation on examination of the semen. Contraception is also included in an excellent manner.

In the concluding chapters, hormones, radiation and physiotherapy, diet, vitamins, and hygiene of the female are given adequate discussions.

This voluminous text certainly covers the field of gynecology adequately with but few exceptions as noted. Subjects such as sterility, contraception, diet and vitamin therapy, and hygiene are welcome additions from the standpoint of the practitioner. This book is more worthwhile from this standpoint than the average. From the student's viewpoint, the lack of references and inadequate treatment of operative therapy are detrimental omissions. For anyone in the practice of medicine the color photographs deserve very favorable comment. If the photomicrographs and line drawings were up to their standard, the book would be worthwhile from this standpoint alone.

J. DONALD WOODRUFF.

FOR many years cardiologists were content with three limb leads as standard technique in recording electrocardiograms, as originally described by Einthoven. During the last decade chest leads were added and universally accepted.

In his book *Unipolar Lead Electrocardiography*[1] Goldberger describes the newest variation in technique, the unipolar leads, originally developed in Wilson's laboratory in Ann Arbor, Michigan. The book is a brief monograph of theory and technique, modestly illustrated, and well indexed. It satisfactorily presents the author's concept of the new method, with his own variations.

The new method is presumed to offer new information by the electrocardiographic method, of the position of the heart in the chest, rotation of the heart (clockwise and counterclockwise), bundle branch block, axis deviation, and ventricular hypertrophy. How practical and how necessary these are to the internists and cardiologists will be answered best by further experience.

CHAUNCEY C. MAHER.

THE monograph *Essai de physiopathologie thyro-hypophysaire; études cliniques, thérapeutiques et expérimentales*[2] by Dr. Mahaux is sufficiently brief and well organized to serve as a guide for reviving European medicine and for its war-time graduates. It is scholarly enough to merit the approval of clinical investigators in the field of endocrinology in any country. The book comprises a few pages on fundamental studies of thyrostimulation in animals, a section on clinical studies of interrelated thyroid and pituitary disorders, and a larger portion which is devoted to the disorders and treatment of the thyroid gland itself. The sources quoted are international and well chosen. The opinions expressed, particularly with respect to the scope, advantages, and complications of the medical thyroinhibitors, are in accord with those of the best qualified American students in the field of thyroid diseases.

EDITH B. FARNSWORTH.

THE monograph of 206 pages *Retropubic Urinary Surgery*[3] is of general value in drawing attention to the possibility of surgical approach by way of the space of Retzius. Millin states that his experience in the treatment of vesical neck obstruction by means of suprapubic (transvesical), perineal, or transurethral surgery has been, in the main, unsatisfactory and he was prompted to seek an improved method. He believes that the retropubic operation which he has devised and popularized answers the need for the improvement he was seeking.

The "cavum Retzius," as he calls it, has been avoided by most surgeons in developing a technique for suprapubic operative procedures. Millin believes that when adequate drainage is provided the retropubic space is no more vulnerable to persistent in-

[1]UNIPOLAR LEAD ELECTROCARDIOGRAPHY; INCLUDING STANDARD LEADS, UNIPOLAR EXTREMITY LEADS AND MULTIPLE UNIPOLAR PRECORDIAL LEADS. By Emanual Goldberger, B.S., M.D. Philadelphia: Lea & Febiger, 1947.

[2]ESSAI DE PHYSIOPATHOLOGIE THYRO-HYPOPHYSAIRE; ÉTUDES CLINIQUES, THÉRAPEUTIQUES ET EXPÉRIMENTALES. By Jacques Mahaux. Paris: Masson & Cie, Editeurs; Liege: Editions Desoer, 1947.

[3]RETROPUBIC URINARY SURGERY. By Terence Millin, M.A., M.Ch. (Dubl.), F.R.C.S., F.R.C.S.I. Baltimore: The Williams & Wilkins Co., 1947.

fection than is the paravesical region. No persistent infection, no osteitis pubis or osteomyelitis of the pubis has been noted by him in any of his patients. He ascribes this complication to injury of the pubic periosteum although many instances of both osteitis pubis and osteomyelitis have been reported in this country following operations upon the bladder and prostate.

Millin recounts the experience of performing 375 prostatectomies since 1945 and his statistics surely indicate that his results have been as good or better than the average similar experience by skillful operators who utilize either the suprapubic or perineal approach.

He reviews the orthodox and accepted views of bladder neck pathology and deals conservatively with preoperative preparation and treatment. A series of brief case reports are included in a short chapter on fluid balance principles.

Millin stresses the ease with which the operation of retropubic prostatectomy can be performed if certain new instruments he describes are used. Postoperative complications are listed rather as possibilities than actual experience in Millin's series. He reports only one instance of major hemorrhage after operation and this is certainly a low incidence.

Millin lists other conditions as suitable for surgical treatment by the retropubic route, such as the fibrous and calculous prostate, the malignant prostate, and rupture of the posterior urethra. Stress incontinence in women is also treated by a rather complicated operation. The author states that he has performed this latter procedure in over 60 cases during the past 3 years with the most gratifying results. No amplification of this statement is given.

It seems questionable to accept Mr. Millin's enthusiasm in applying this operation to the fibrous prostate and other vesical neck obstructions of minor prostatic enlargements. Transurethral resection achieves an excellent result in these patients with less subjective upset. If Young's insistence, in carcinoma of the prostate, on a total removal of the seminal vesicles and their related fascia is accepted as true and essential by advocates of radical perineal prostatectomy in America, Millin's procedure cannot satisfy this criterion in carcinoma of the prostate.

Millin gives the impression of having a great personal enthusiasm for his work and undoubtedly has developed a most meticulous technique. He is a very skillful surgeon. The monograph gives the impression of having been compiled rather hurriedly and without the scientific, detailed case analyses which we would like to study.

Millin has undoubtedly made a valuable contribution to prostatic surgery. Time must elapse before a scientific evaluation of retropubic prostatectomy can be made. In the meantime many men will be operated upon by this method and large numbers of patients can be studied carefully so that the end-results and late complications of these groups can be compared to similar groups treated by the suprapubic (transvesical) and the perineal routes. These two latter methods, despite their drawbacks, have persistently been the routes of choice by most surgeons for more than a generation. VINCENT J. O'CONOR.

THE text *Operative Gynecology*[1] by Crossen and Crossen has been revised and renewed extensively. Despite the alterations that have been made the present edition, the sixth, contains about 75 less pages than the fifth edition. Actually new operations and more illustrations have been added. Many of the historical notes on operations, which appeared in the earlier editions, have been deleted or condensed.

The section on radiotherapy is noteworthy in its discussion of the management of myoma uteri. Gratifying results can be obtained when great care is exercised in the selection of suitable cases for this type of treatment. With the recognition of definite indications and contraindications, irradiation therapy can prove to be a valuable addition to the gynecologist's surgical skills.

Prevention of carcinoma is emphasized and treatment of the diseased cervix is particularly stressed. Carcinoma *in situ* (intraepithelial carcinoma) is not mentioned or discussed. All gynecologists will not agree that the involuting uterus and ovaries should be removed in each case in which any one of the pelvic structures requires operation.

The chapters on anesthesia and the intestinal tract in relationship to gynecology have been well revised and rewritten by H. S. Brooks, Jr.

The volume has been carefully and thoroughly planned and well deserves to be a standard reference for the gynecologist. GEORGE A. HAHN.

THE book *Rheumatism and Soft Tissue Injuries*[2] by James Cyriax, deals with painful soft tissue lesions. Lesions of the fascia, bursae, tendons, muscles, and ligaments, of obscure etiology and appearing for no obvious reason, have been classified under the rather broad term "rheumatism." The author attempts to clarify the nature of these vague pathologic painful conditions by a system of diagnostic measures based upon clinical findings. The localization of the lesion to a definite tissue is based on a logical system of examination.

The book is divided into chapters dealing with various anatomic divisions of the body, with methods for examination of each part. Appropriate treatment, chiefly physical therapy, is discussed in detail for each lesion and part involved.

Many theories are advanced to explain abscure pathology, and these may be accepted or rejected by the reader according to his views.

The book is well illustrated with line drawings and excellent photographs, and should be of interest to physical therapists and those specialists dealing with the musculoskeletal system. WILLIAM A. LARMON.

[1]OPERATIVE GYNECOLOGY. By Harry Sturgeon Crossen, M.D., and Robert James Crossen, M.D. 6th ed. St. Louis: The C. V. Mosby Co., 1948.

[2]RHEUMATISM AND SOFT TISSUE INJURIES. By James Cyriax, M.D., B.Ch. (Cantab.). New York and London: Paul B. Hoeber, Inc., 1946.

A NEW edition of the well known and practical *Textbook of General Surgery*[1] has been brought up to date by the authors and nineteen collaborators and represents one of the finest textbooks available for the student of general surgery.

The subject matter emphasizes the fundamentals of physiology and pathology. There are many excellent illustrations of gross and microscopic pathology. The diagnosis and treatment of conditions encountered in the realm of general surgery are discussed in a manner both concise and adequate.

The material on nutritional requirements of surgical patients has been expanded in keeping with the growing interest in this field. There is an excellent chapter on surgical diseases of the chest. The section on war and catastrophe surgery has been rewritten and is a valuable chapter on military surgery.

For the most part, surgical procedures are not described in too great detail, but this does not detract from the book's value as a text. The fundamental principles of surgical treatment are clearly defined and each chapter is terminated by a well chosen and up to date bibliography which affords an excellent reference list. EDWARD W. GIBBS.

THE author's long experience in the radiology of the gastrointestinal tract gives him a peculiarly valuable preparation for the production of this reference and textbook on *The Digestive Tract in Roentgenology*[2]. The text is complete. A very gratifying inclusion is a well selected list of references to the literature appended to each chapter. For the most part the illustrations are satisfactory. Some of the poorer illustrations are of rare cases in which the author had little choice. Careful perusal of this book impresses one with its value as a cyclopedic discussion of the subject of radiology connected with the digestive and biliary tracts. All things considered, this work probably rates as the best publication on radiology of the digestive tract in any language up to the present writing. JAMES T. CASE.

THE author presents a simple, clear, easy to follow discussion in his book entitled *Coronary Heart Disease*[3]. In the introductory chapter he states that the progressive increase of this disease during the past 45 years has been the principal factor in the rise of heart disease to the leading place as a cause of death in this country. Ernstene continues with a general statement covering the difficulties of diagnosis which often arise followed by a brief but concise discussion of the fundamental causes of the disease and the important changes in the electrocardiogram which corroborate a diagnosis.

The remaining chapters in the book are devoted to the principal clinical manifestations of coronary heart disease: angina pectoris, acute myocardial infarction, acute coronary failure, paroxysmal cardiac dyspnea (cardiac asthma), auriculoventricular and intraventricular block, other disturbances of cardiac rhythm and congestive heart failure. The conditions are clearly presented with their distinctive clinical picture or diagnostic changes in the electrocardiogram and the treatment of each as it differs in important respects from that of the other.

The discussion of each condition is clear, logical, and comprehensive in the limited number of pages. One very important feature is his free use of excellent references from the medical literature, chiefly of recent date. In addition his discussion of the use of various acceptable forms of treatment is highly adequate and should prove most helpful to the practitioner. GEORGE C. TURNBULL.

THE increasing interest shown in respiratory physiology in its relationship to the application of inhalation therapy makes *Physiologic Therapy in Respiratory Diseases*[4] particularly timely. A general review of anoxia and its treatment is followed by a practical application of these physiologic principles to the management of the most common conditions in which alterations of normal gaseous exchange occur. The interrelated use of aerosols and their role in the treatment of these pathologic processes is presented. Problems in aviation and war medicine are discussed and a practical, simple, yet detailed description of the methods and apparatus for inhalation is presented. Contributions to the current literature in regard to apparatus and methods have been numerous and this compilation makes a valuable reference compendium to the subject, not only in recent developments but in such "established" apparatus as oxygen tents masks, respirators, oxygen analyzers, etc. Clear illustrations, charts, and case histories, and chapter bibliographies add to the clarity of presented data. Of particular interest is the discussion of the equalizing pressure chamber and its role in the management of pulmonary tuberculosis, particularly in those cases hitherto classified as "hopeless."

Although this book is of special interest to the anesthesiologist, internist, and surgeon, it should be of value to those in all fields of medicine. There are few specialists who would not find something of practical interest in this book; it should be of broad interest to all practitioners. EDWARD BIGG.

[1] TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., F.A.C.S., and Robert Elman, M.D., F.A.C.S. 5th ed. New York and London: D. Appleton-Century Co., Inc., 1948.

[2] THE DIGESTIVE TRACT IN ROENTGENOLOGY. By Jacob Buckstein, M.D. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1948.

[3] CORONARY HEART DISEASE. By A. Carlton Ernstene, M.D. Springfield, Ill.: Charles C Thomas, 1948.

[4] PHYSIOLOGIC THERAPY IN RESPIRATORY DISEASES. By Alvan L. Barach, M.D. 2nd ed. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1948.

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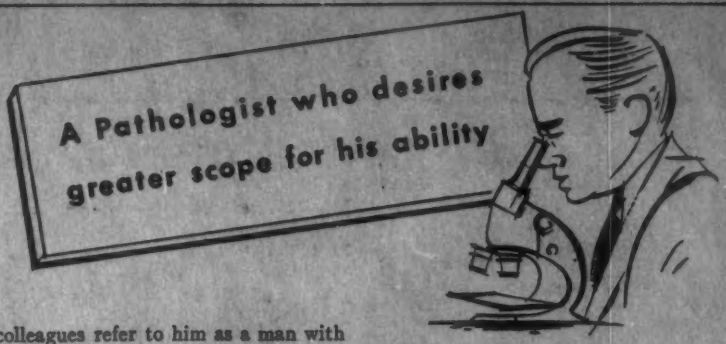

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